Global Climate Change

Impact on the Upper Midwest

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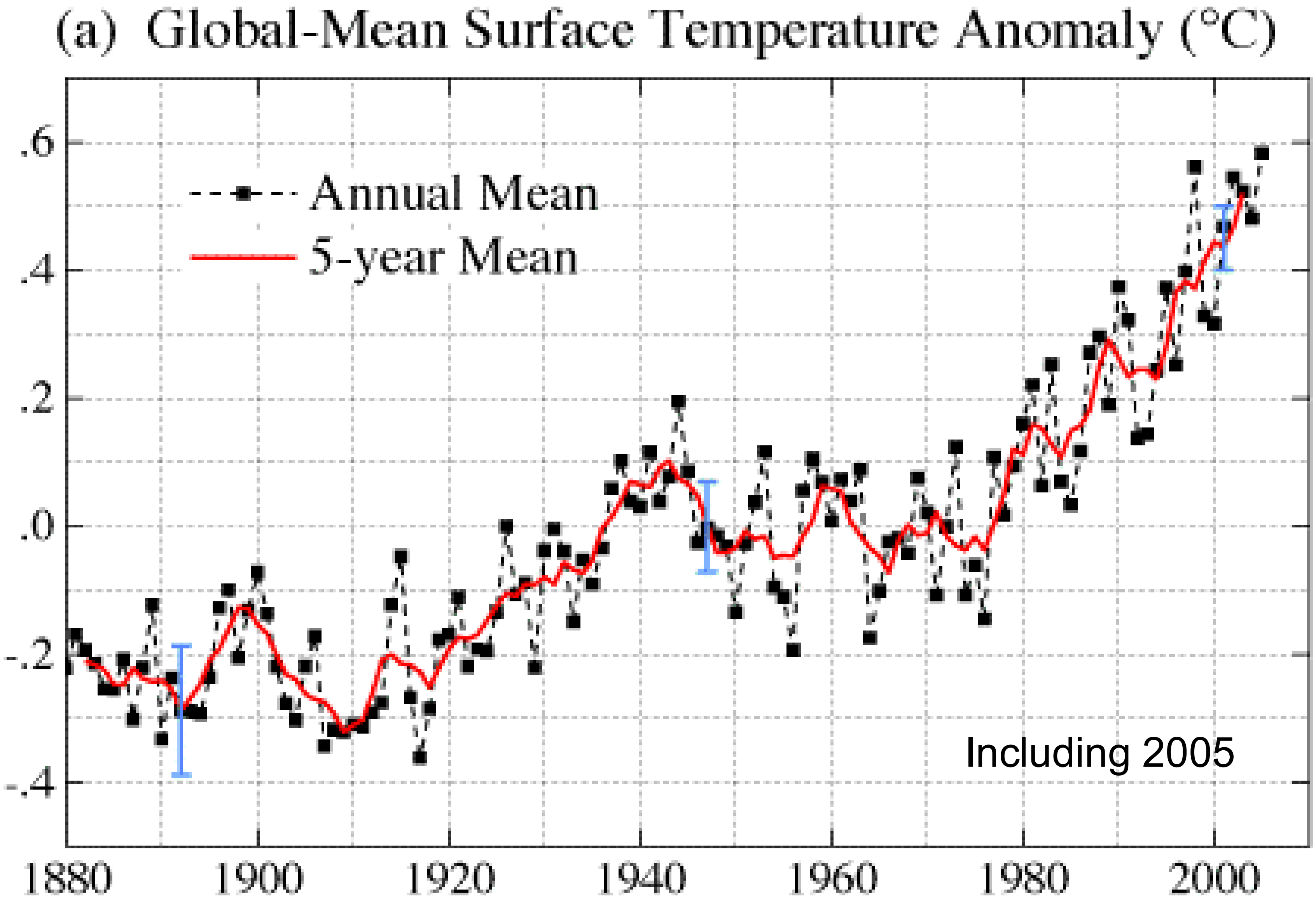
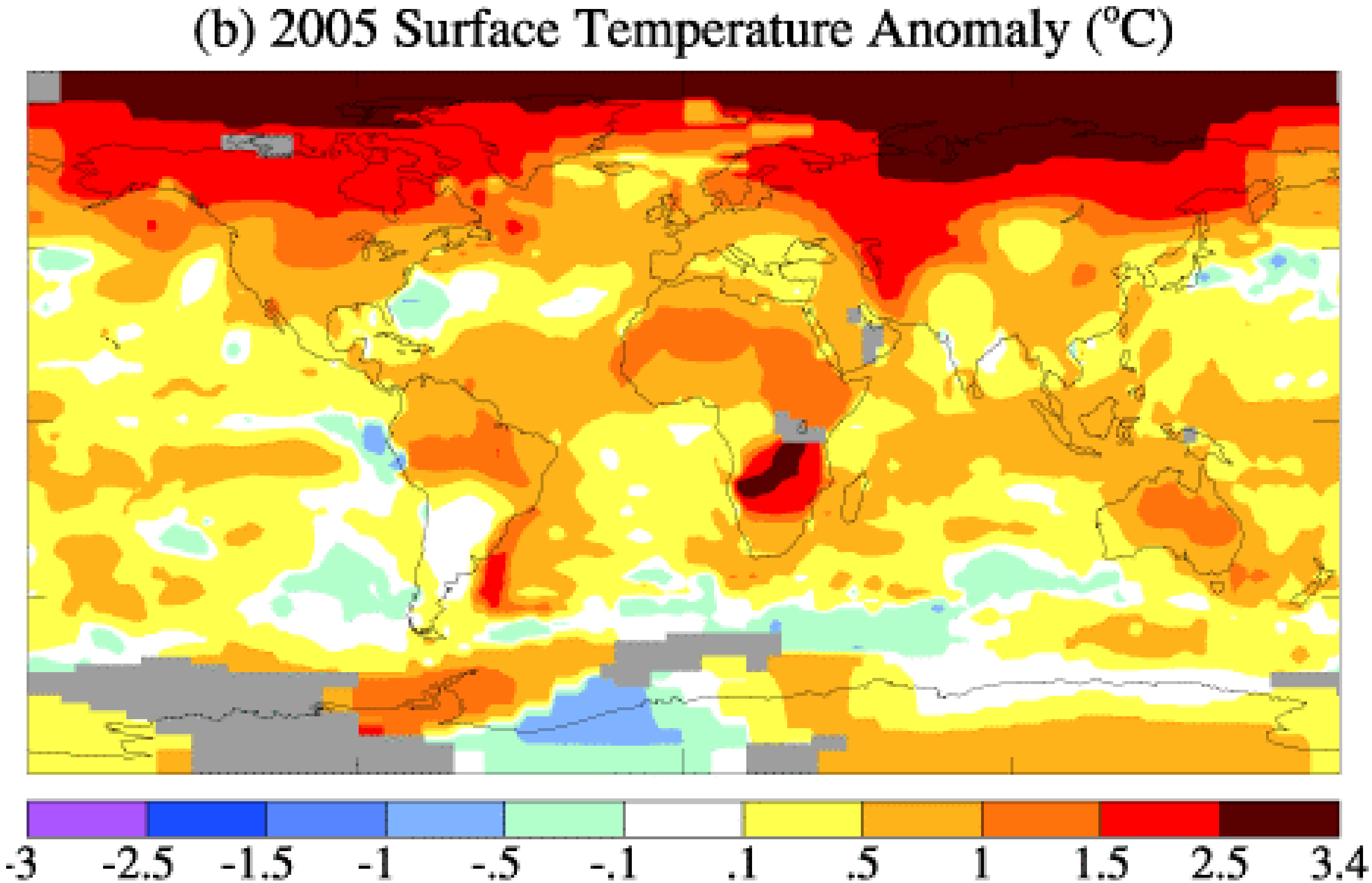
David D. Houghton
Atmospheric & Oceanic Sciences
UW – Madison
Email: ddhought@wisc.edu

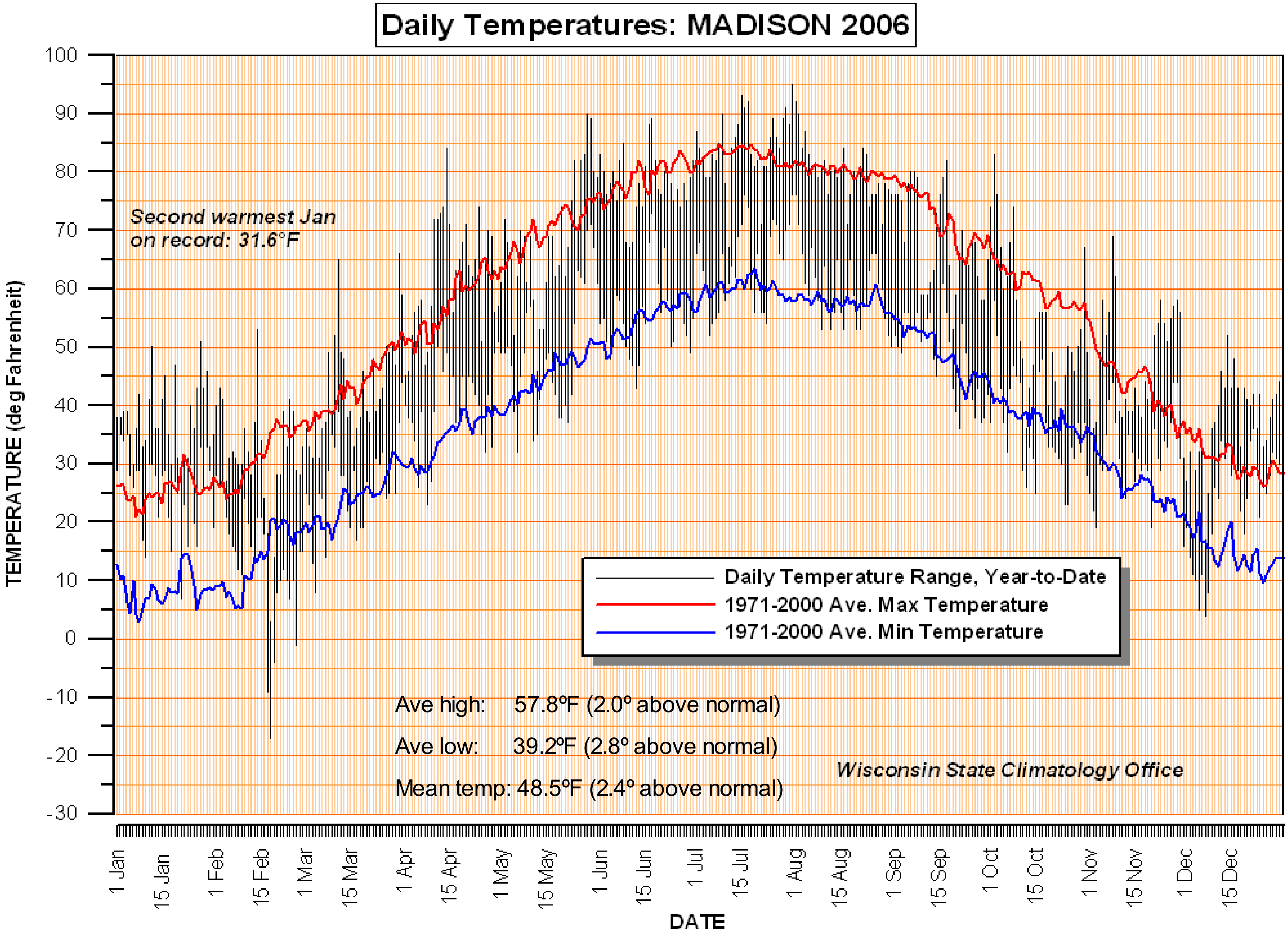
Outline

1. Introduction
2. Going from global to regional scale
3. Trends in US in last 25 years
4. Predictions
5. Implications for Wisconsin ecosystems
6. Impacts: agriculture, health, economic
7. What can we do about it
8. Discussion

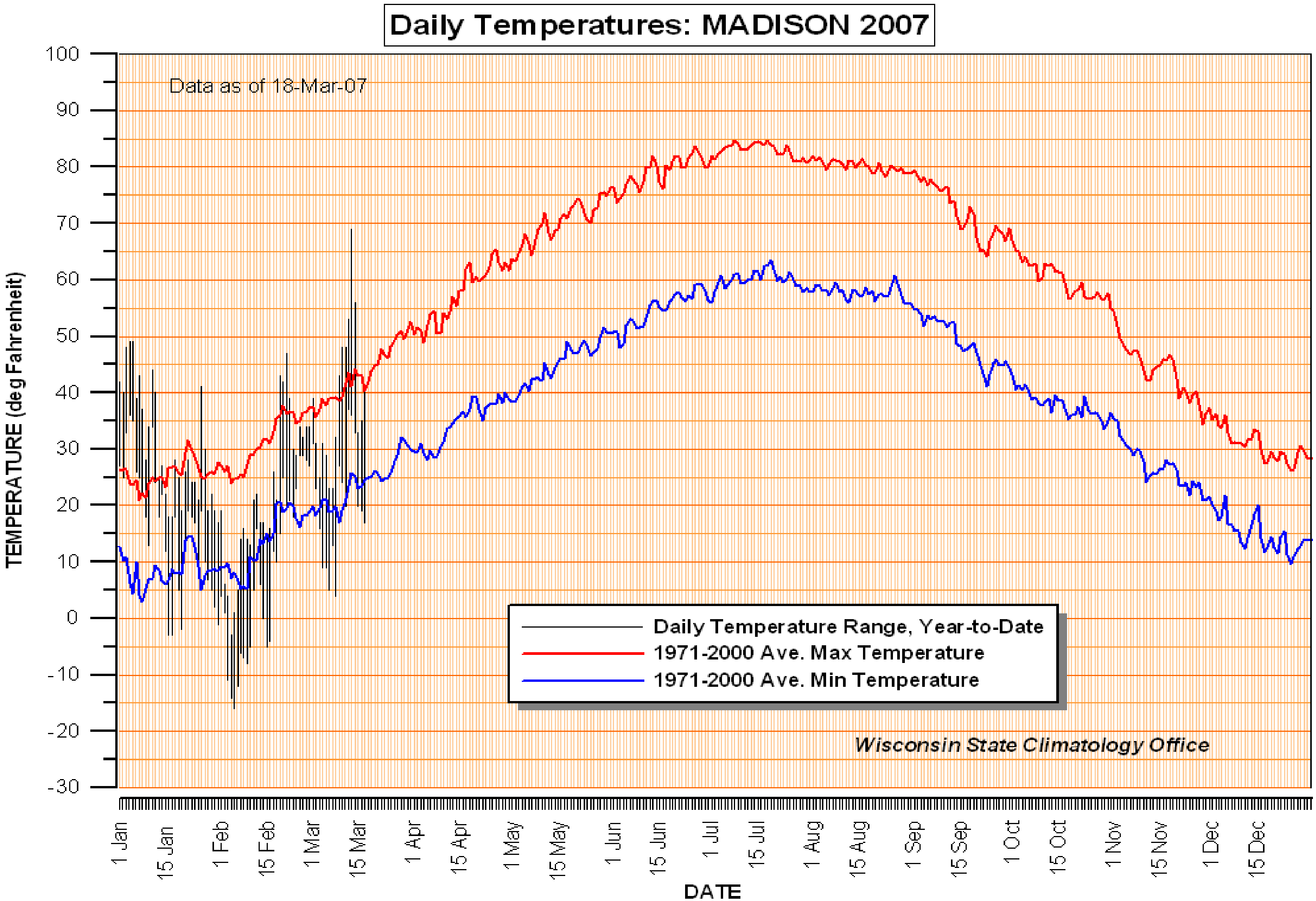
Going from Global to Regional and Local Scale


(a) Global-Mean Surface Temperature Anomaly (°C)
Annual Mean
5-year Mean
Including 2005
.6
.4
.2
.0
-.2
-.4
1880
1900
1920
1940
1960
1980
2000


(b) 2005 Surface Temperature Anomaly (°C)
-3
-2.5
-1.5
-1
-.5
-.1
.1
.5
1
1.5
2.5
3.4



Daily Temperatures: MADISON 2006
TEMPERATURE (deg Fahrenheit)
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
Second warmest Jan
on record: 31.6°F
Daily Temperature Range, Year-to-Date
1971-2000 Ave. Max Temperature
1971-2000 Ave. Min Temperature
Ave high: 57.8ºF (2.0º above normal)
Ave low: 39.2ºF (2.8º above normal)
Mean temp: 48.5ºF (2.4º above normal)
Wisconsin State Climatology Office
1 Jan
15 Jan
1 Feb
15 Feb
1 Mar
15 Mar
1 Apr
15 Apr
1 May
15 May
1 Jun
15 Jun
1 Jul
15 Jul
1 Aug
15 Aug
1 Sep
15 Sep
1 Oct
15 Oct
1 Nov
15 Nov
1 Dec
15 Dec
DATE



Daily Temperatures: MADISON 2007
Data as of 18-Mar-07
TEMPERATURE (deg Fahrenheit)
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
1 Jan
15 Jan
1 Feb
15 Feb
1 Mar
15 Mar
1 Apr
15 Apr
1 May
15 May
1 Jun
15 Jun
1 Jul
15 Jul
1 Aug
15 Aug
1 Sep
15 Sep
1 Oct
15 Oct
1 Nov
15 Nov
1 Dec
15 Dec
DATE
Daily Temperature Range, Year-to-Date
1971-2000 Ave. Max Temperature
1971-2000 Ave. Min Temperature
Wisconsin State Climatology Office

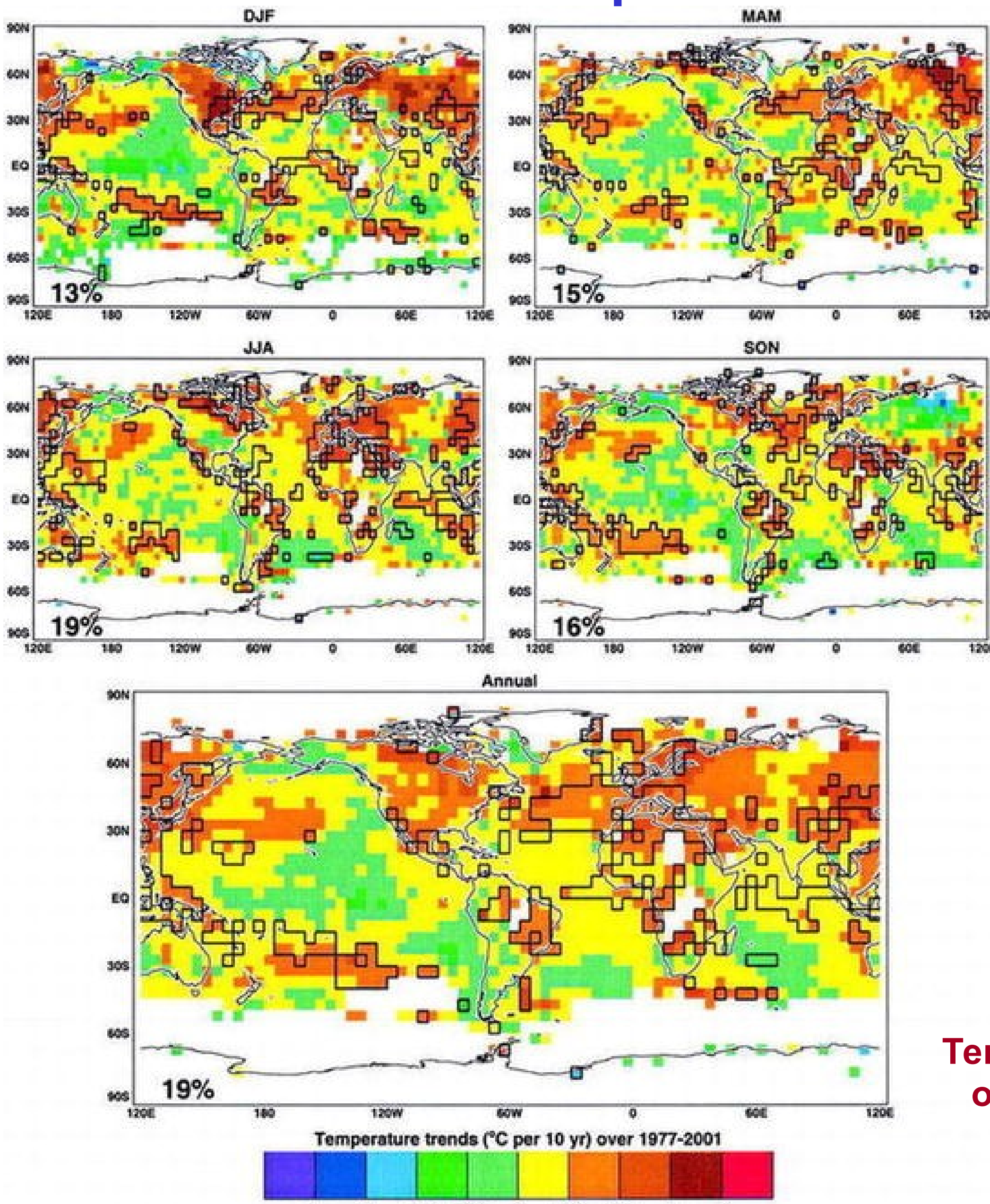
Global, Regional, and Local Trends in the last 25 years

Regional and Seasonal Temperature Trends

Winter
and
Spring

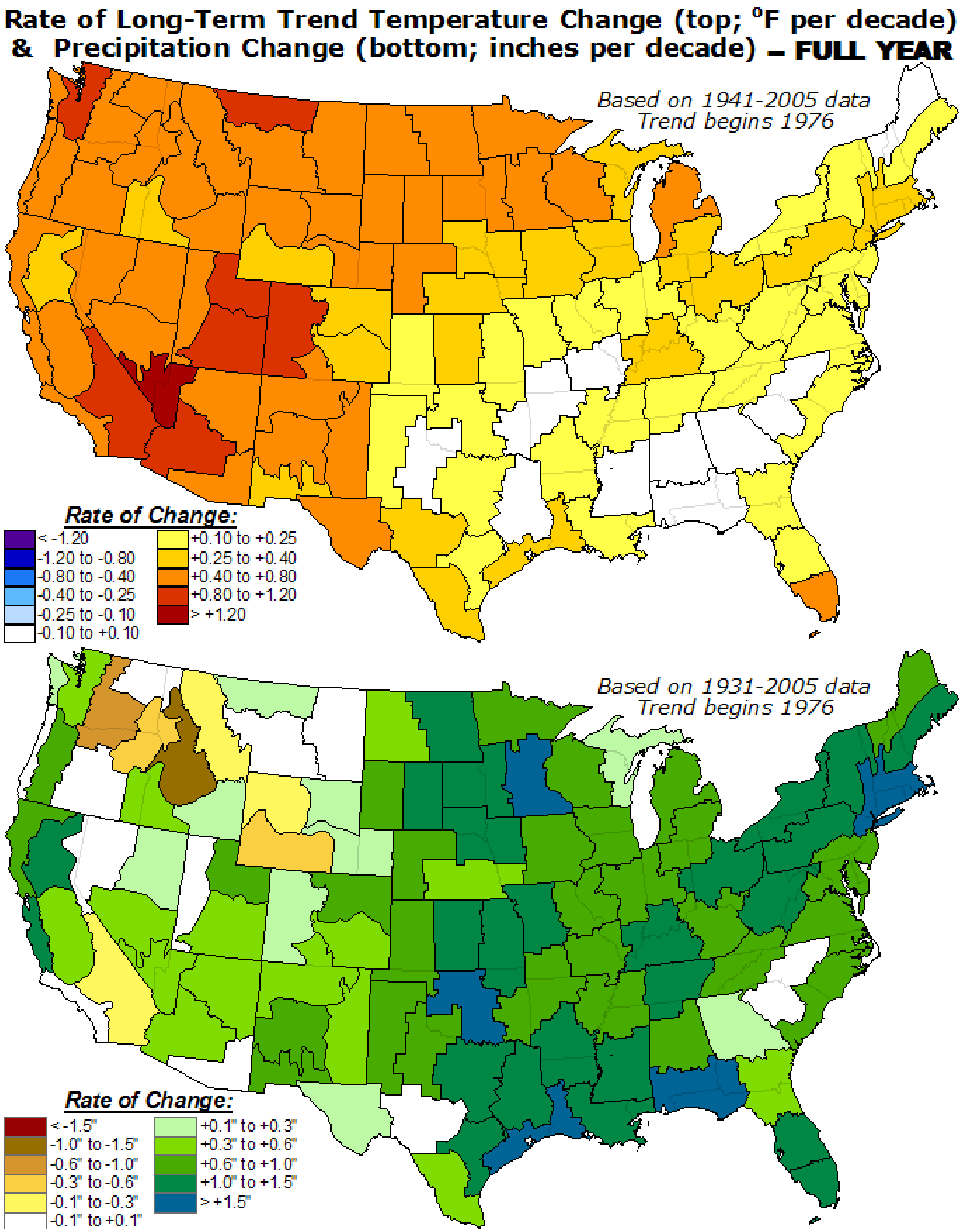
Summer
and
Autumn

Annual
Average

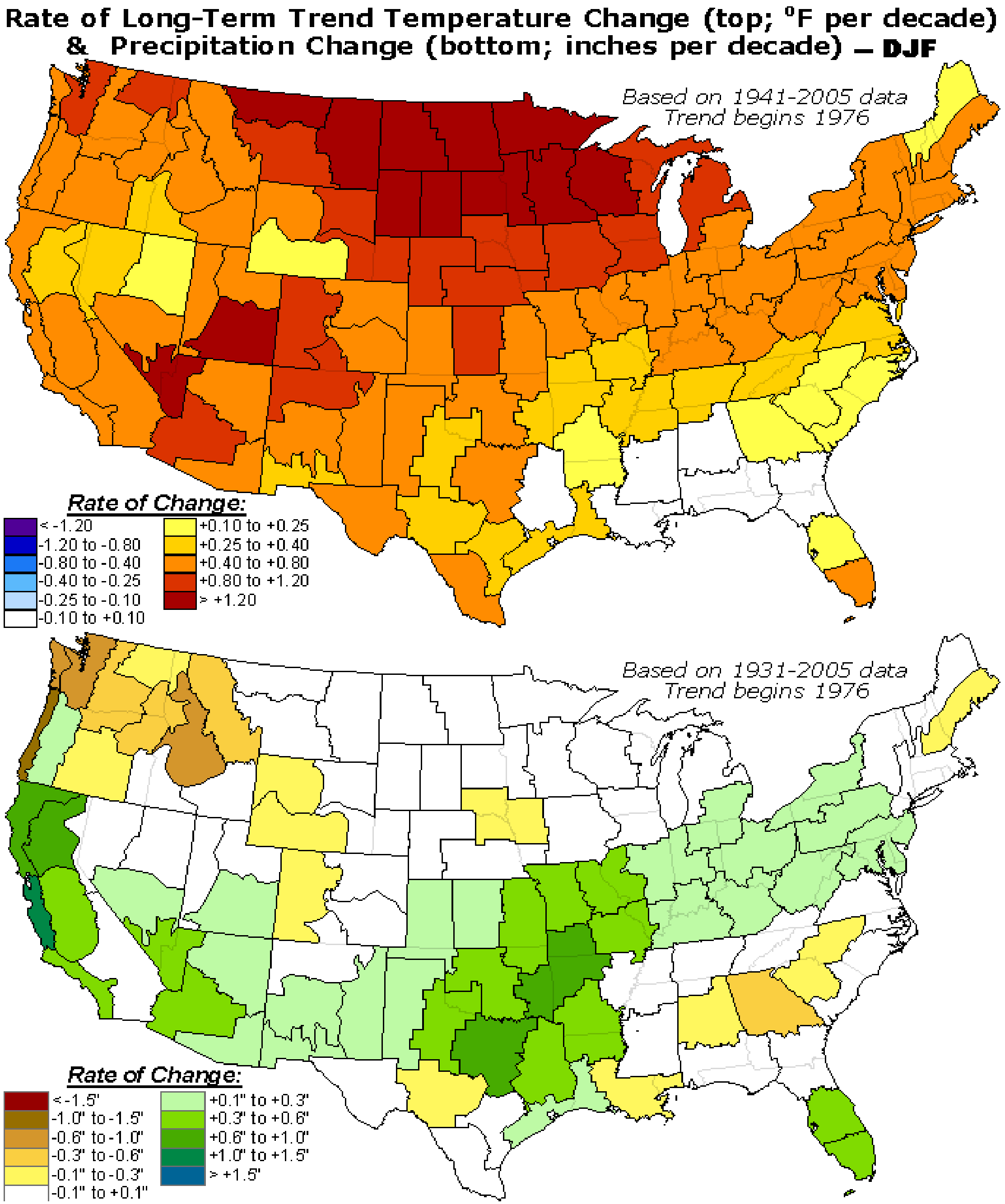


Temperature trends over 1977-2001

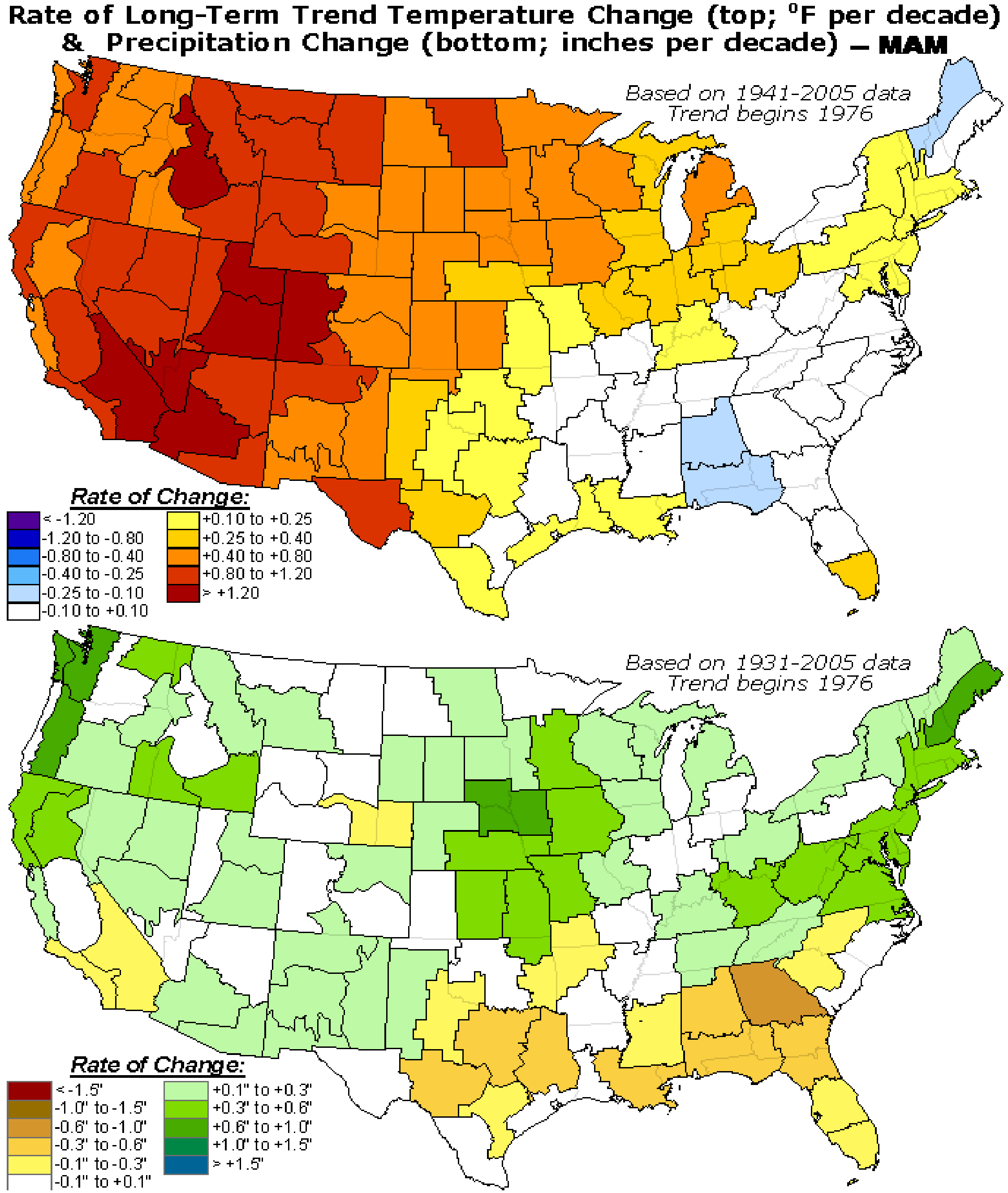
Annual-mean trends from 1976 for temperature and precipitation



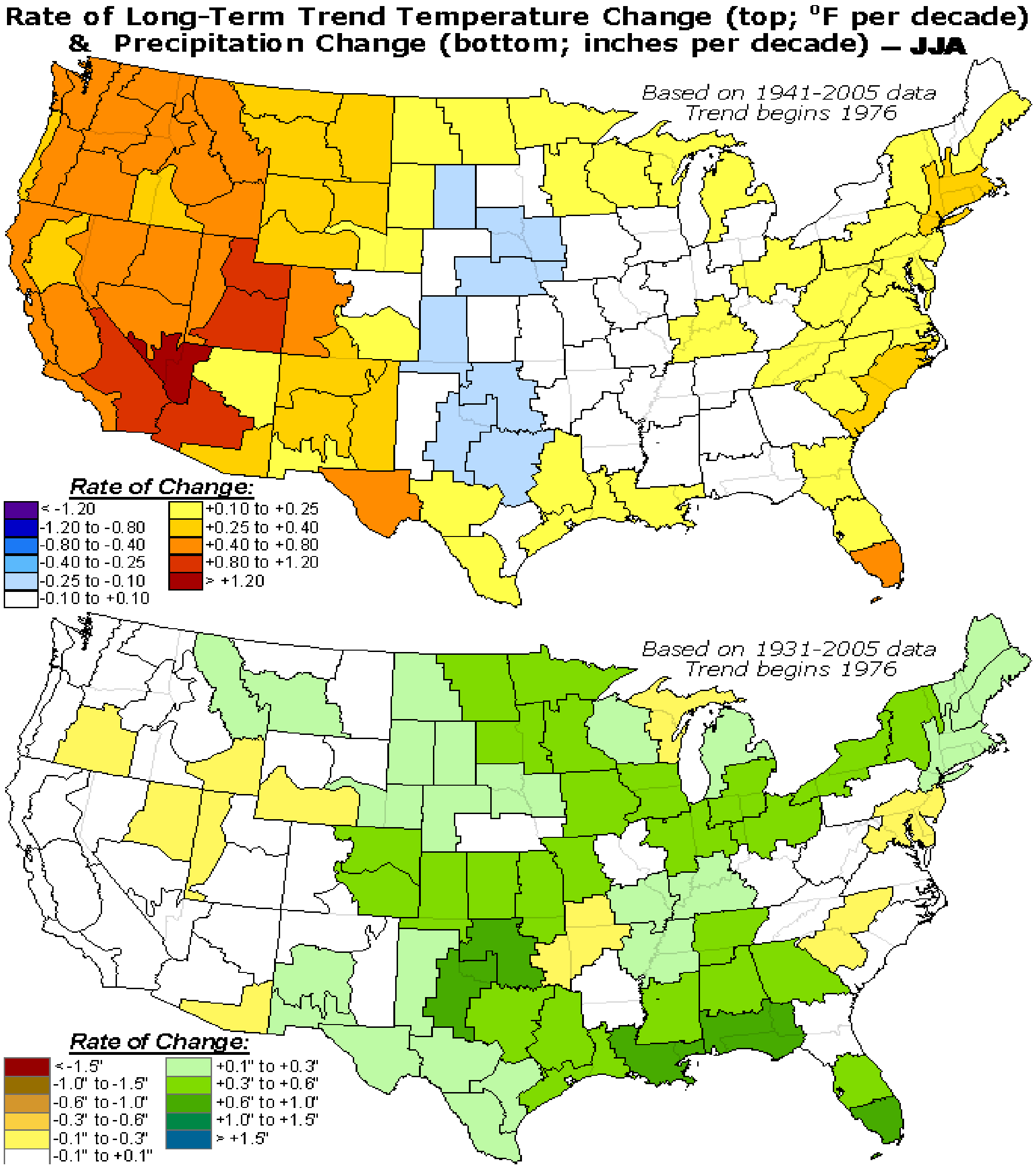
Winter-mean trends since 1976 for temperature and precipitation



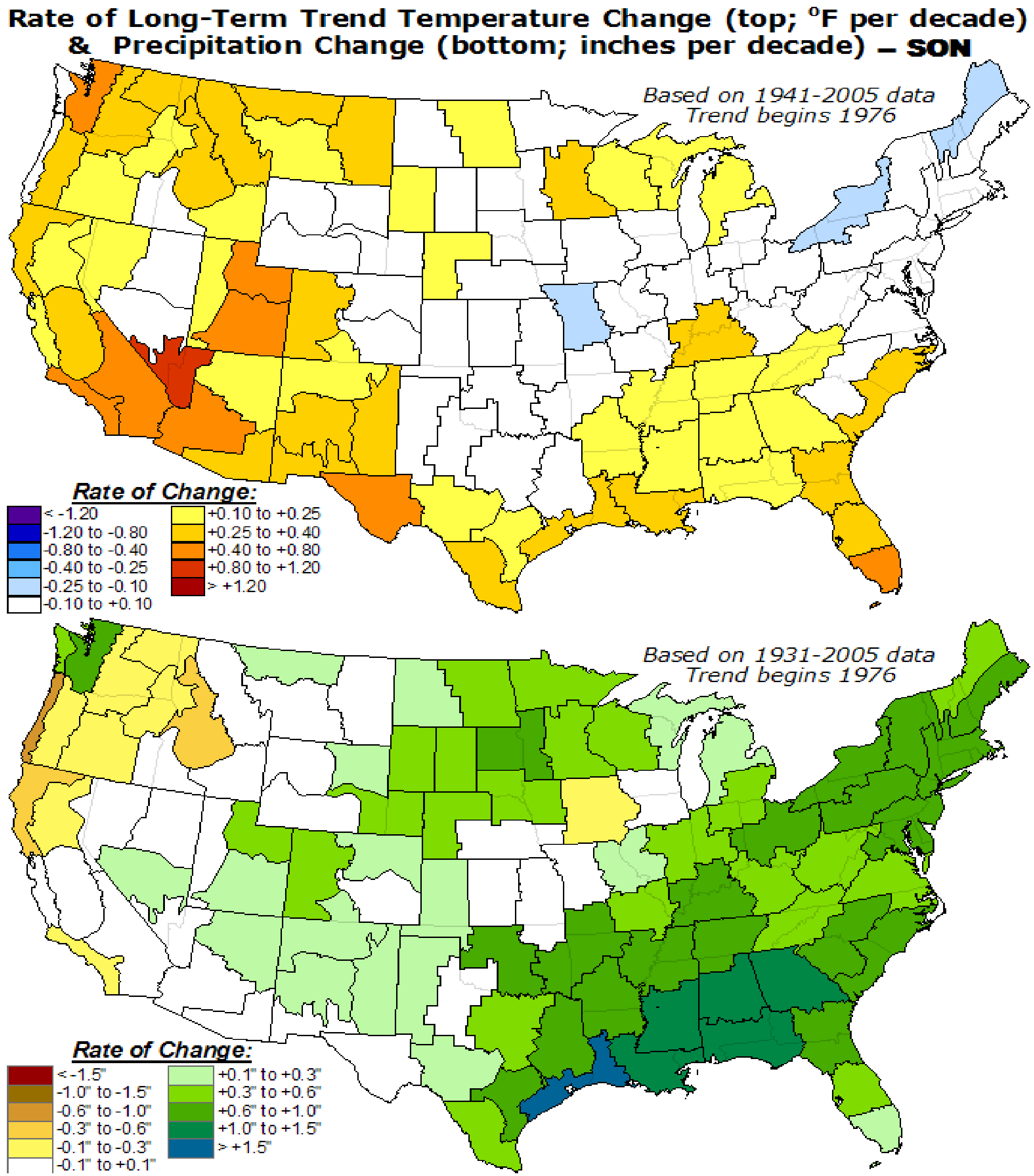
Spring-mean trends since 1976 for temperature and precipitation



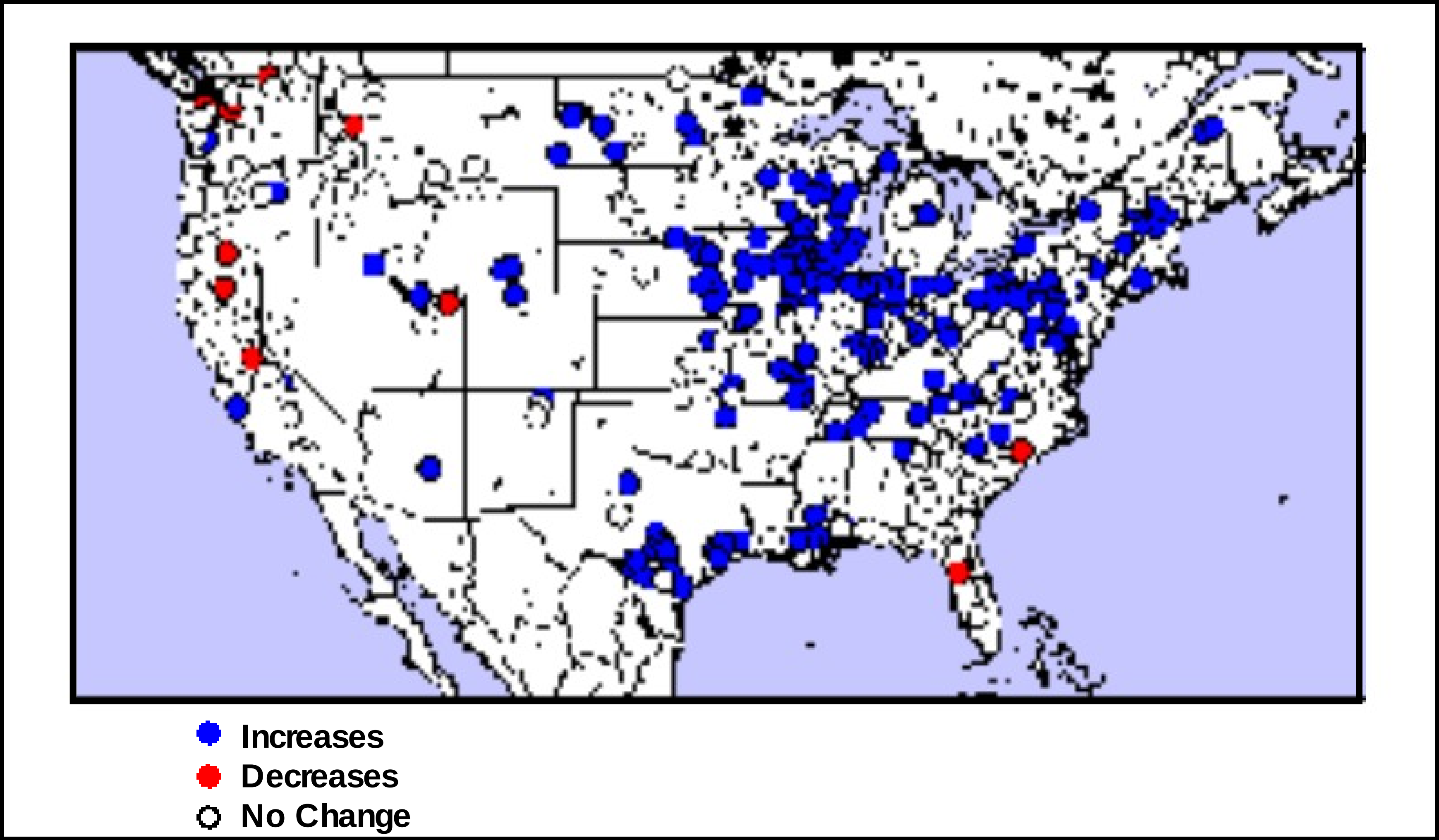
Summer-mean trends since 1976 for temperature and precipitation



Fall-mean trends since 1976 for temperature and precipitation

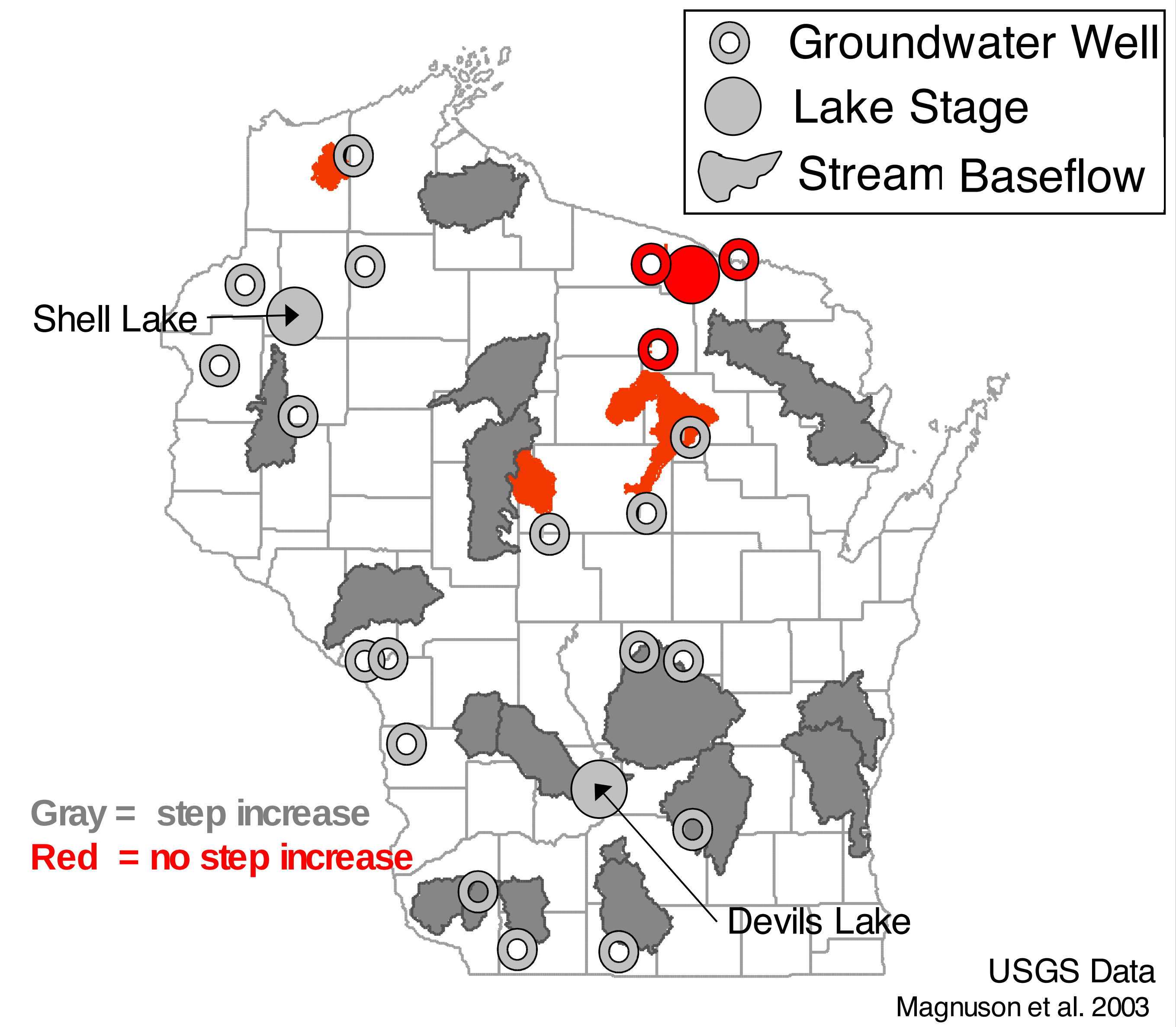


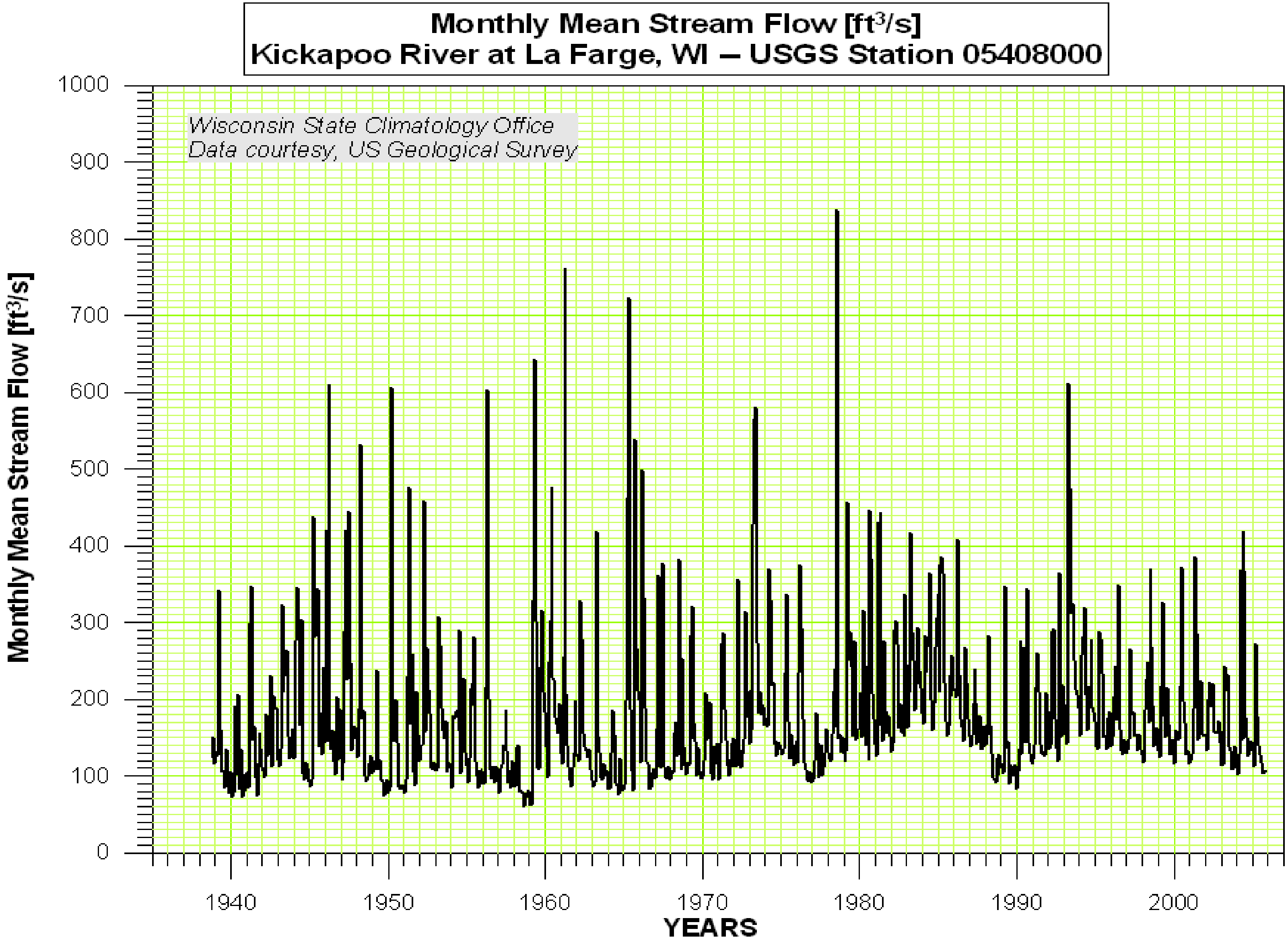
Stream-flow Sites with Significant Increases in Minimum Daily Flow between Two Periods (1941-70 and 1971-99)



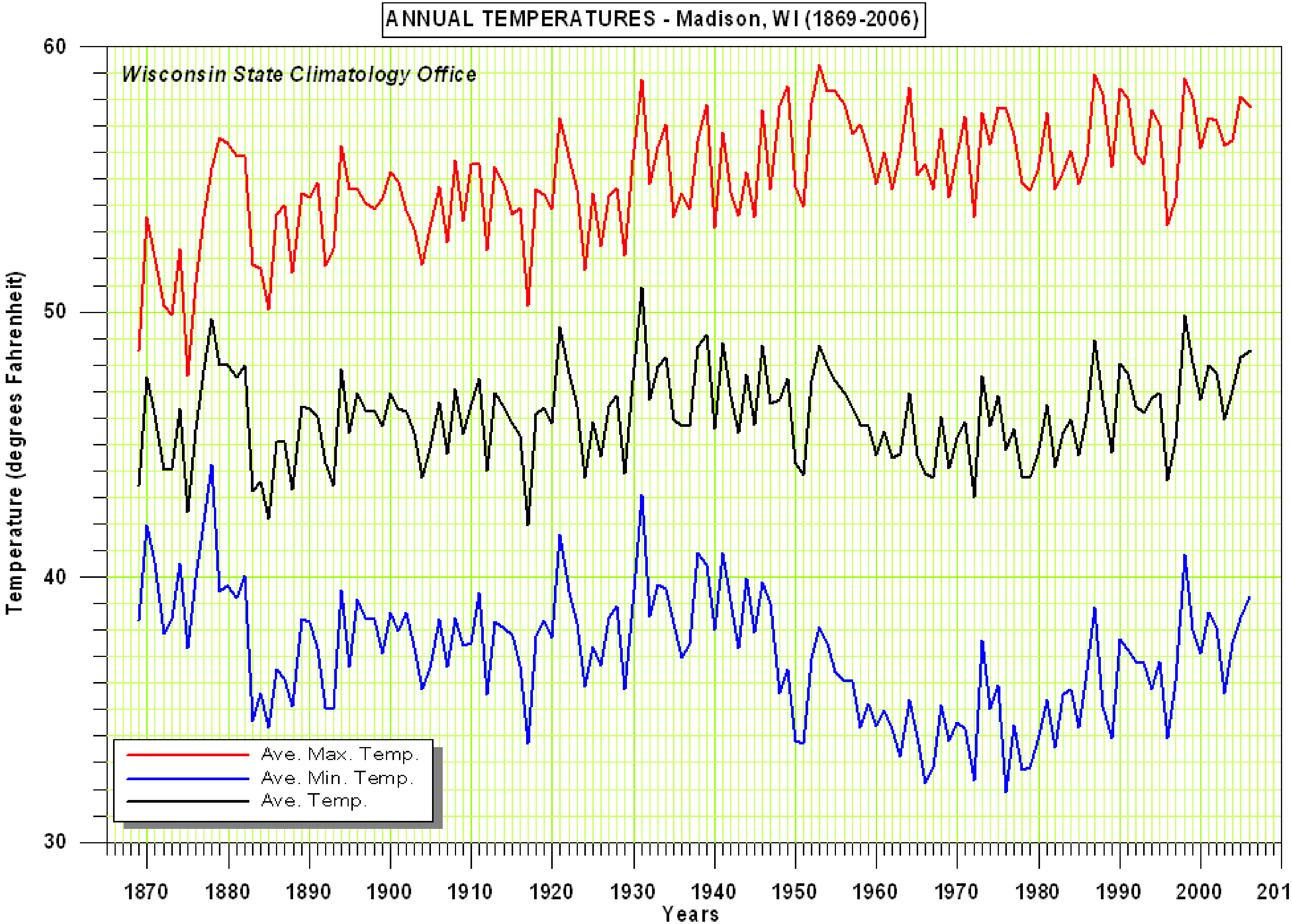
McCabe and Wolock

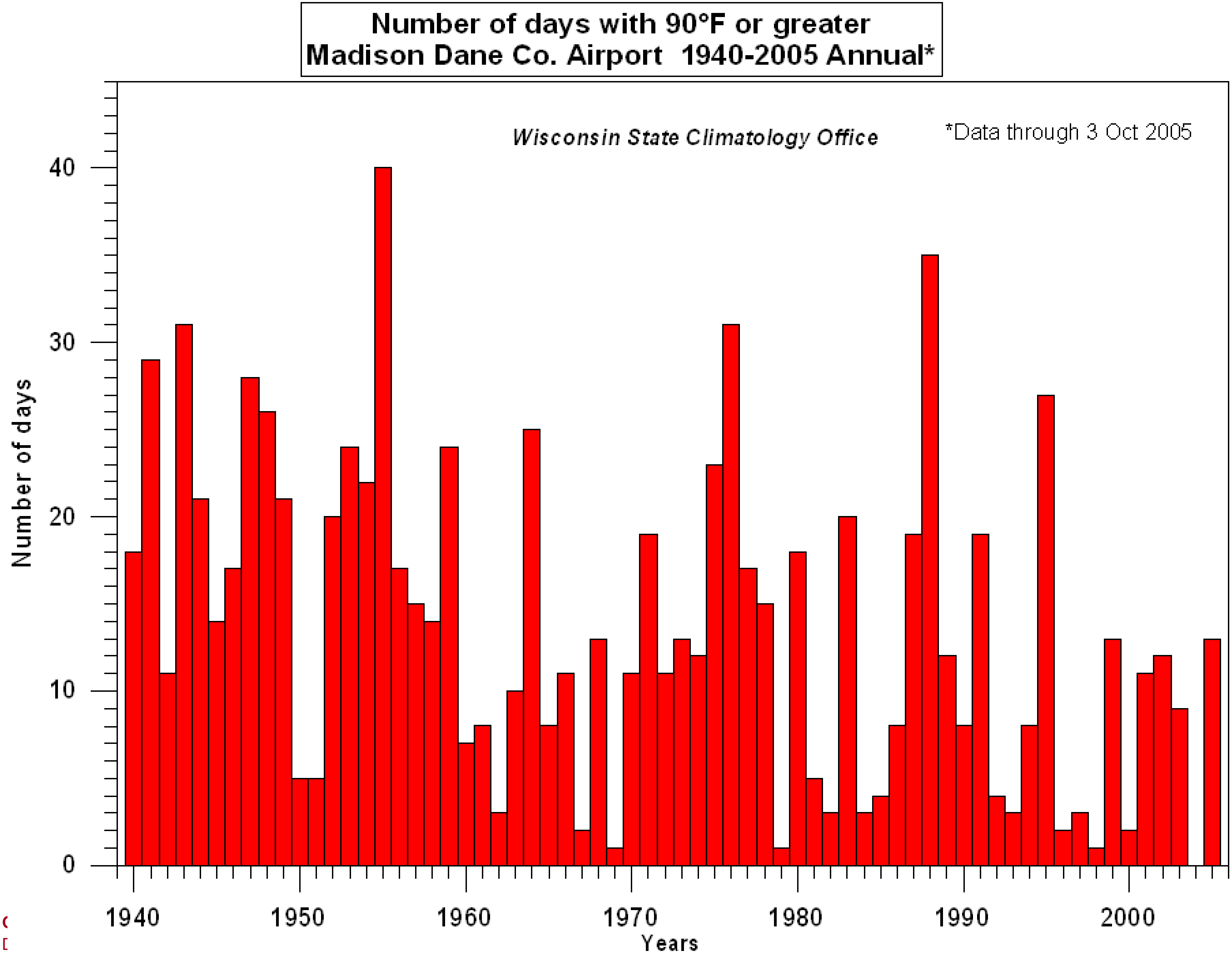
Step Increase in Lake Stage, Stream Flow, and Groundwater Levels after 1970



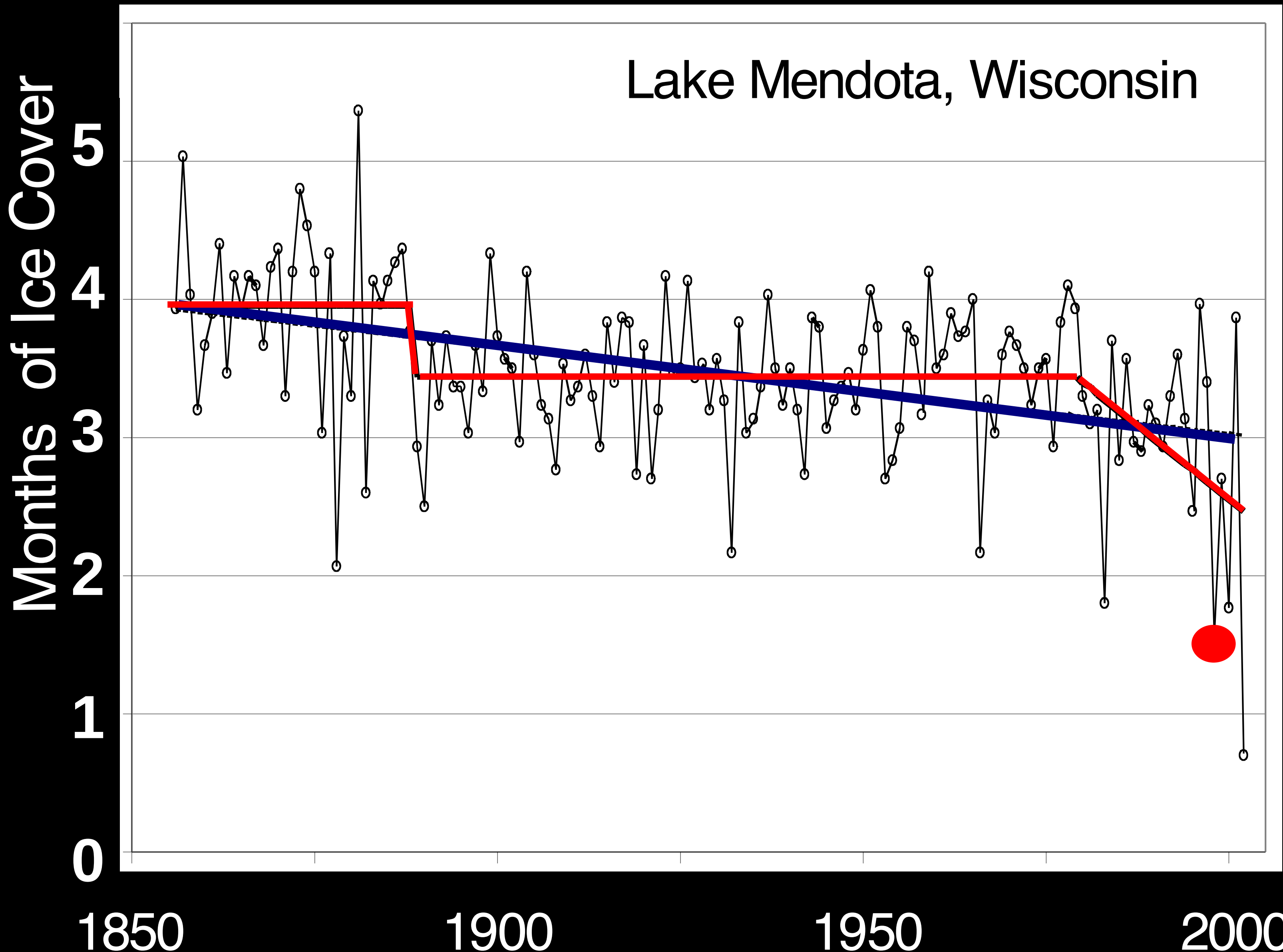


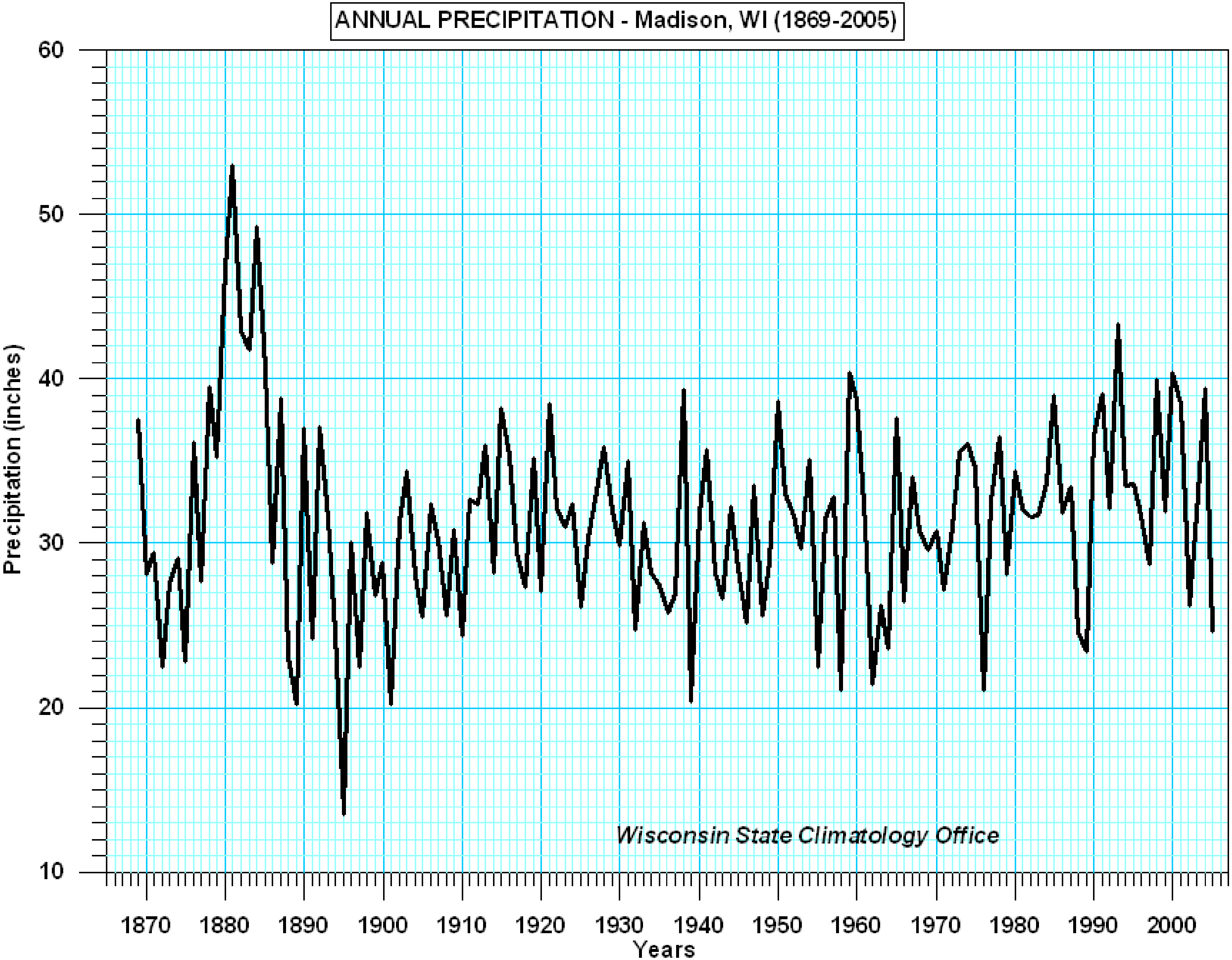
Monthly Mean Stream Flow [ft³/s]
Kickapoo River at La Farge, WI – USGS Station 05408000
Wisconsin State Climatology Office
Data courtesy, US Geological Survey
Monthly Mean Stream Flow [ft³/s]
1000
900
800
700
600
500
400
300
200
100
0
1940
1950
1960
1970
1980
1990
2000
YEARS


ANNUAL TEMPERATURES - Madison, WI (1869-2006)
Wisconsin State Climatology Office
Temperature (degrees Fahrenheit)
60
50
40
30
1870
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
Years
Ave. Max. Temp.
Ave. Min. Temp.
Ave. Temp.


Number of days with 90°F or greater
Madison Dane Co. Airport 1940-2005 Annual*
Wisconsin State Climatology Office
*Data through 3 Oct 2005
Number of days
0
10
20
30
40
1940
1950
1960
1970
1980
1990
2000
Years

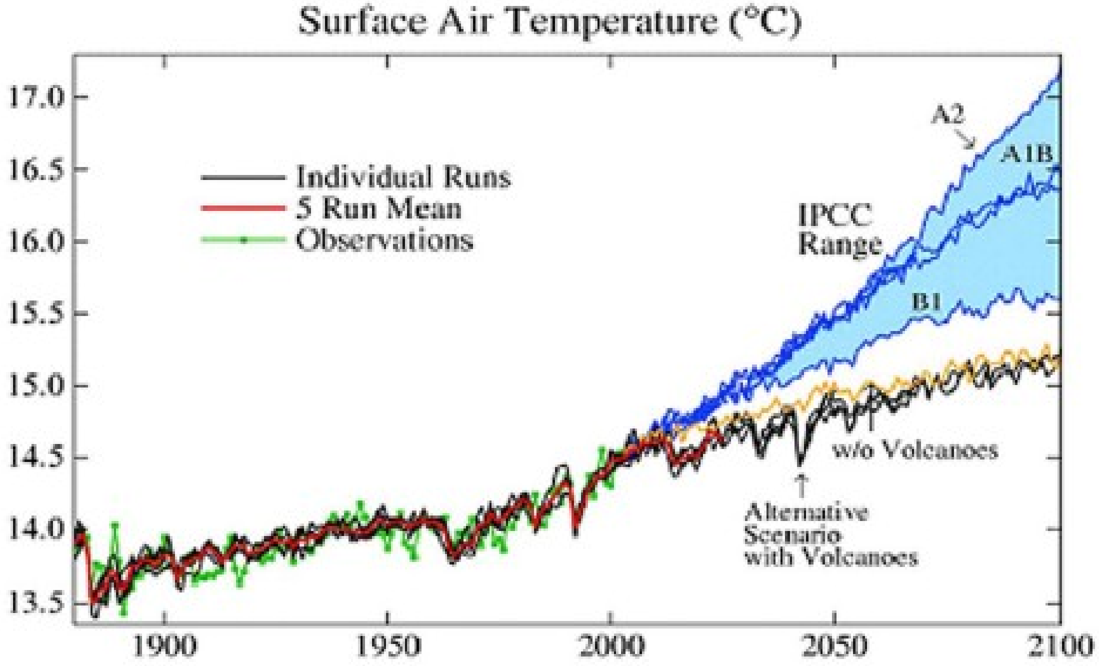
Long-Term Changes in Ice Cover Duration




ANNUAL PRECIPITATION - Madison, WI (1869-2005)
Precipitation (inches)
60
50
40
30
20
10
1870
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
Years
Wisconsin State Climatology Office

Predictions

21st Century Global Warming

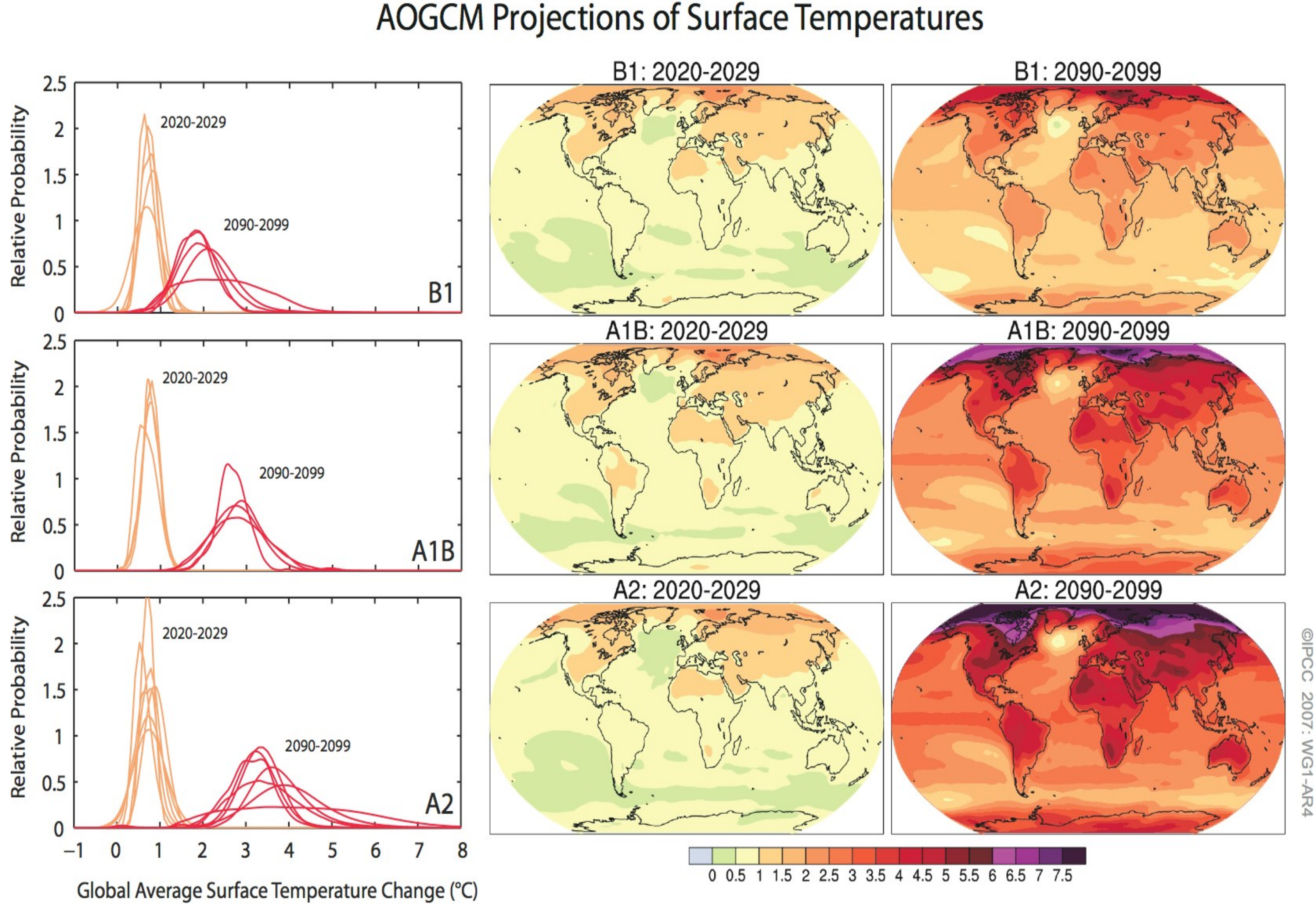


Climate Simulations for IPCC 2007 Report

- **Climate Model Sensitivity ~ 2.7°C for $2xCO_2$**
  (consistent with paleoclimate data & other models)
- **Simulations Consistent with 1880-2003 Observations**
  (key test = ocean heat storage)
- **Simulated Global Warming < 1°C in Alternative Scenario**

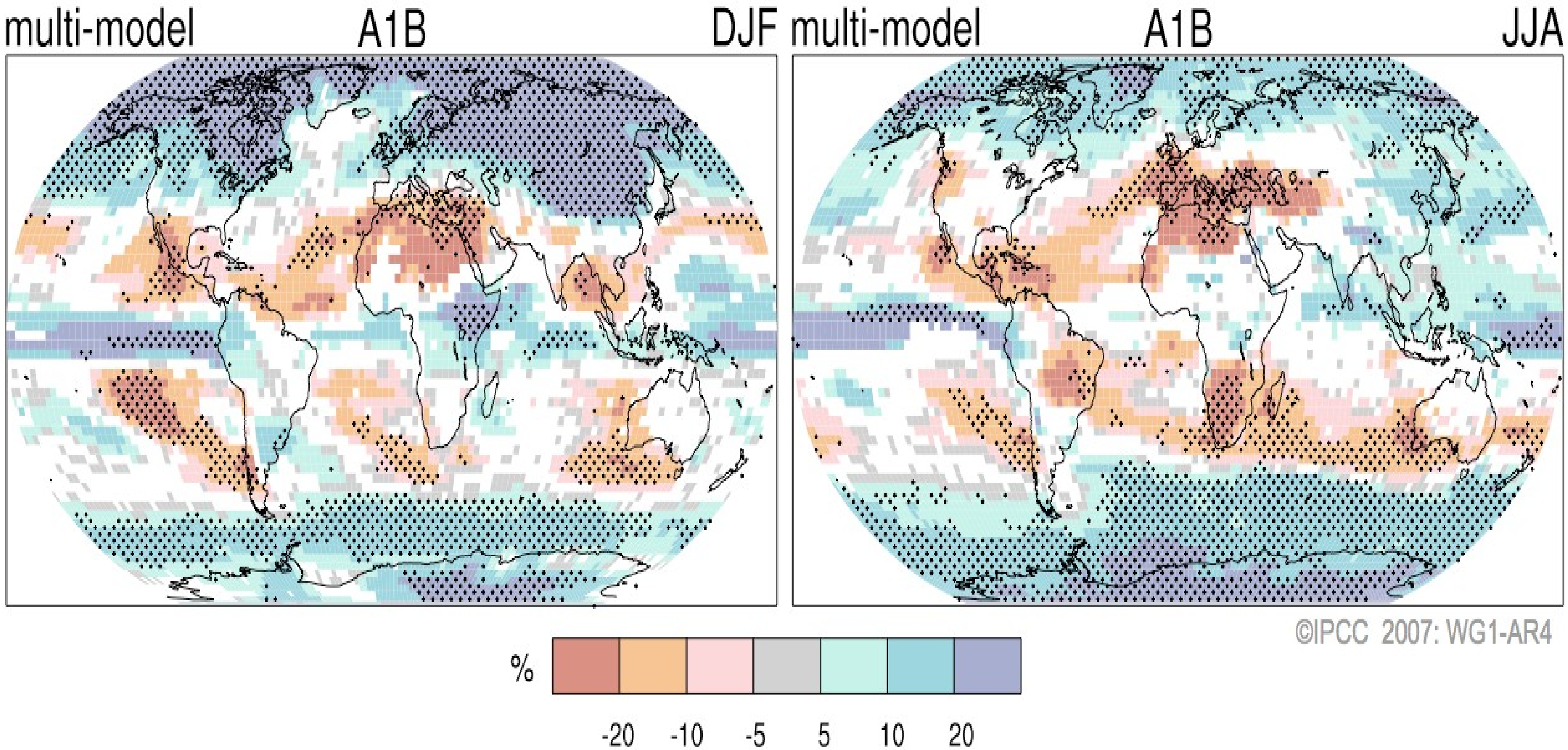
Conclusion: Warming < 1°C if additional forcing ~ 1.5 W/m^2 25

Source: Hansen et al., *to be submitted to J. Geophys. Res.*



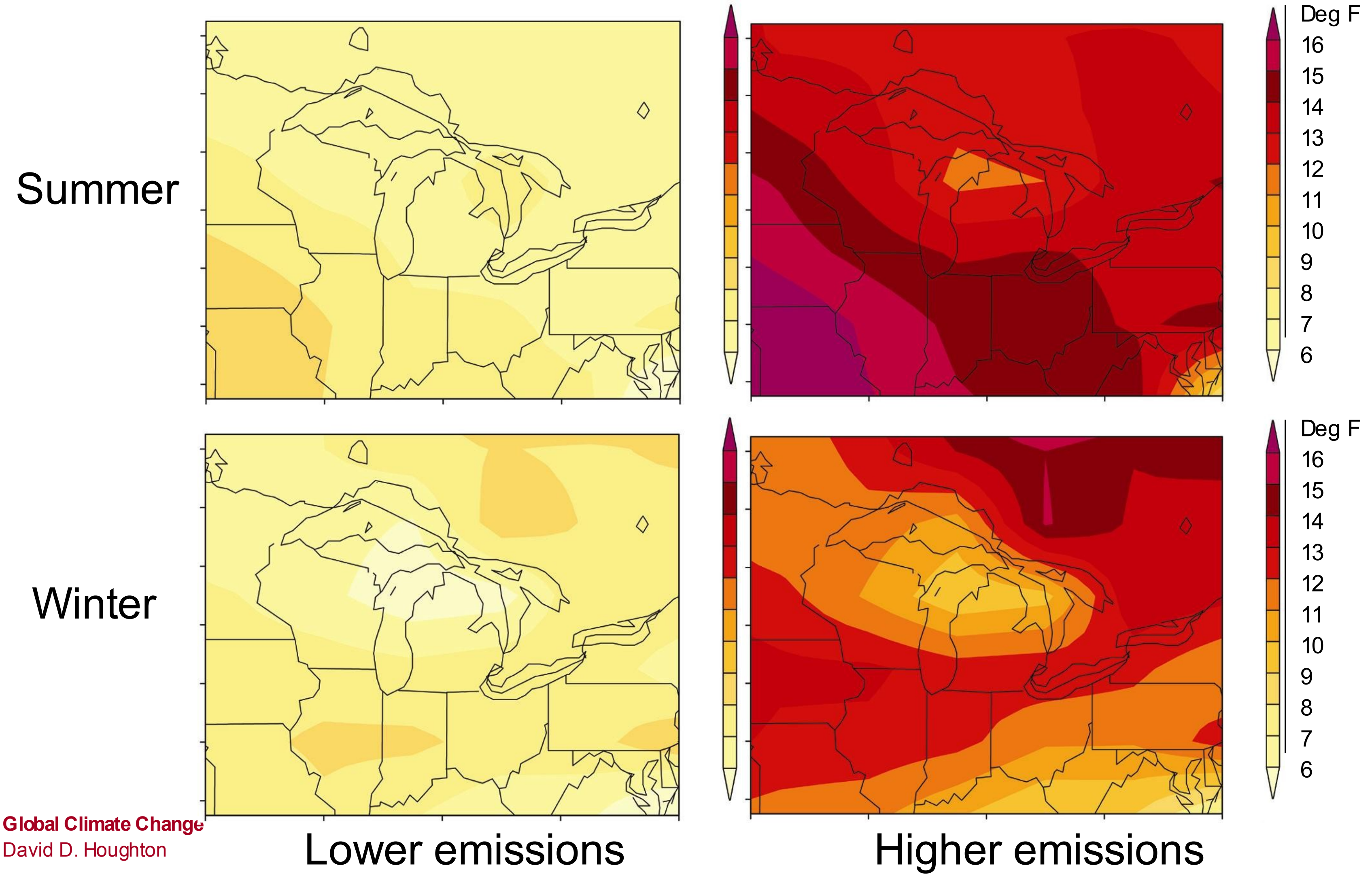
Climate Model predictions for temperature changes for the rest of the 21st century – IPCC 4th Report. Spread of uncertainties of probabilities from the different models used shown on left side.

Projected Patterns of Precipitation Changes

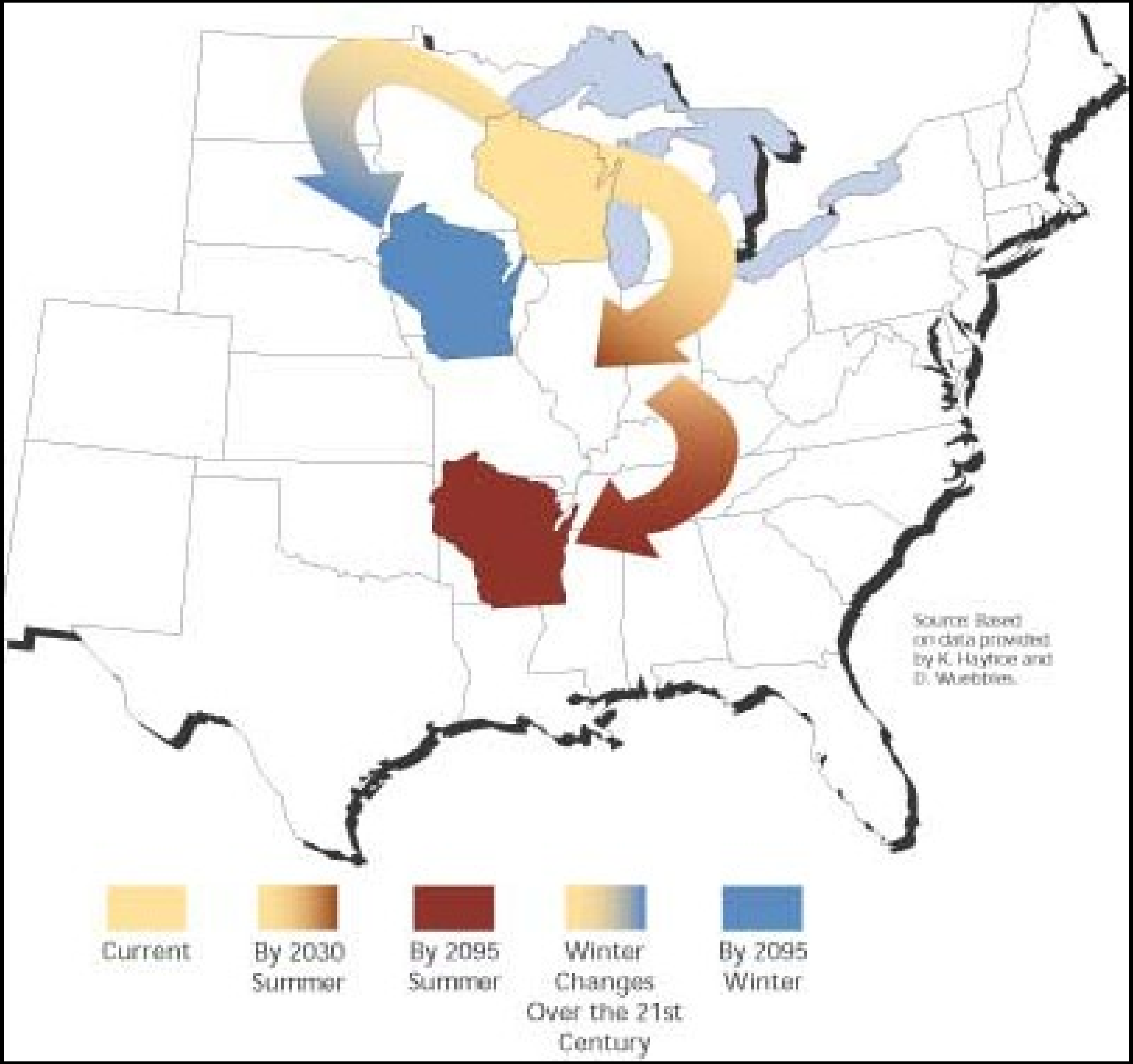


Precipitation changes from 1980-99 to 2090-99 from group of climate models for IPCC 4th Report. Stippled area – more than 90% of the models agree to the sign of the change. White areas where less than 66% of the models agree to the sign of the change.

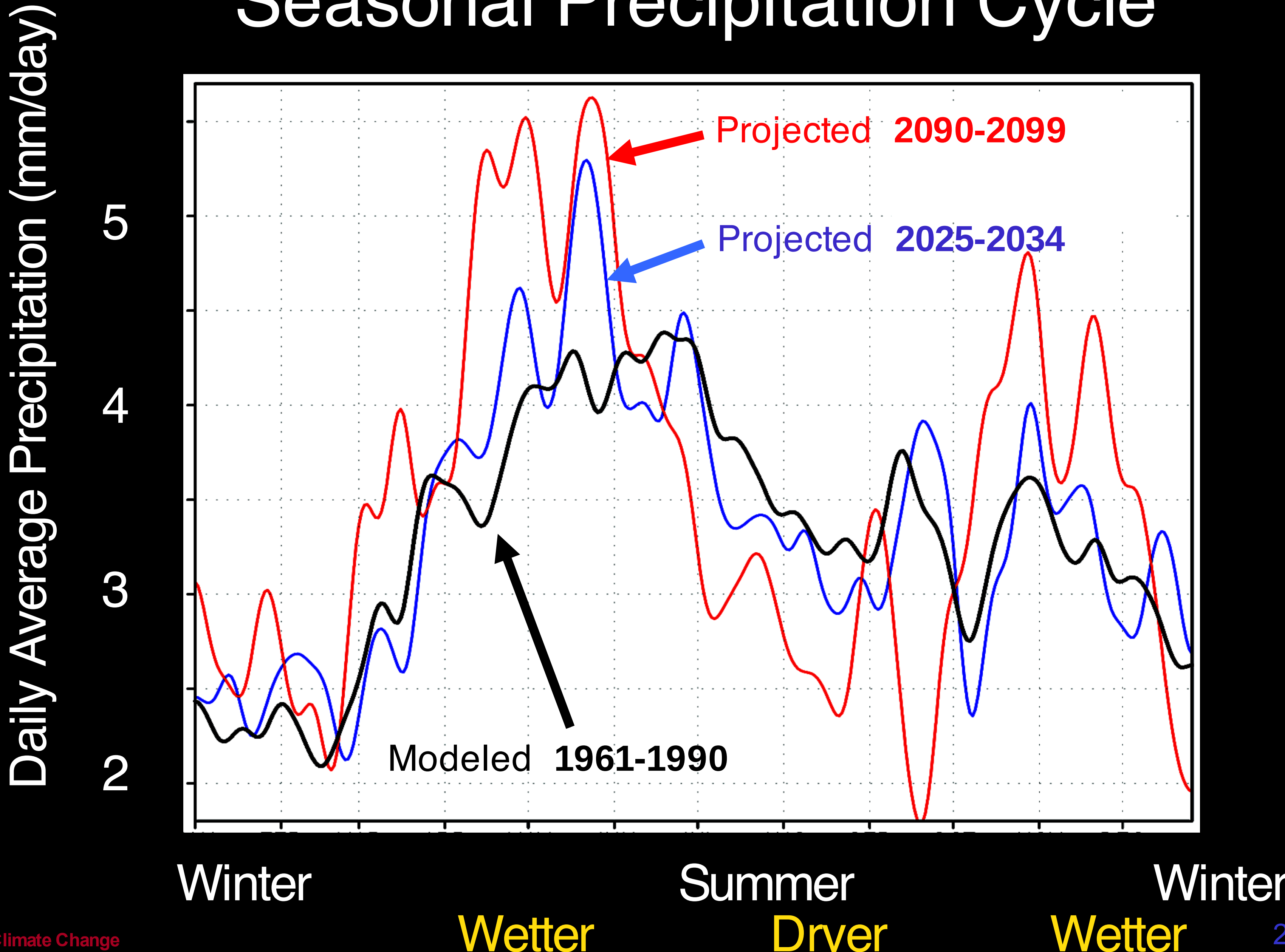
Projected Temperature Increase in the Great Lakes Region (by 2070-99)



Moving States - What happened to winter?



Seasonal Precipitation Cycle



UCS/ESA 2003

Main Points of Confronting Climate Change in the Great Lakes Region

1. Climate is changing globally and in our region.

2. Impacts have already occurred and will get worse.

3. Emissions of greenhouse gases especially CO_2 contribute to these changes.

4. Actions taken now can reduce the most severe future impacts.

UCS & ESA 2003.

Implications for Wisconsin Ecosystems

Climate Change Impacts on Humans & the Environment

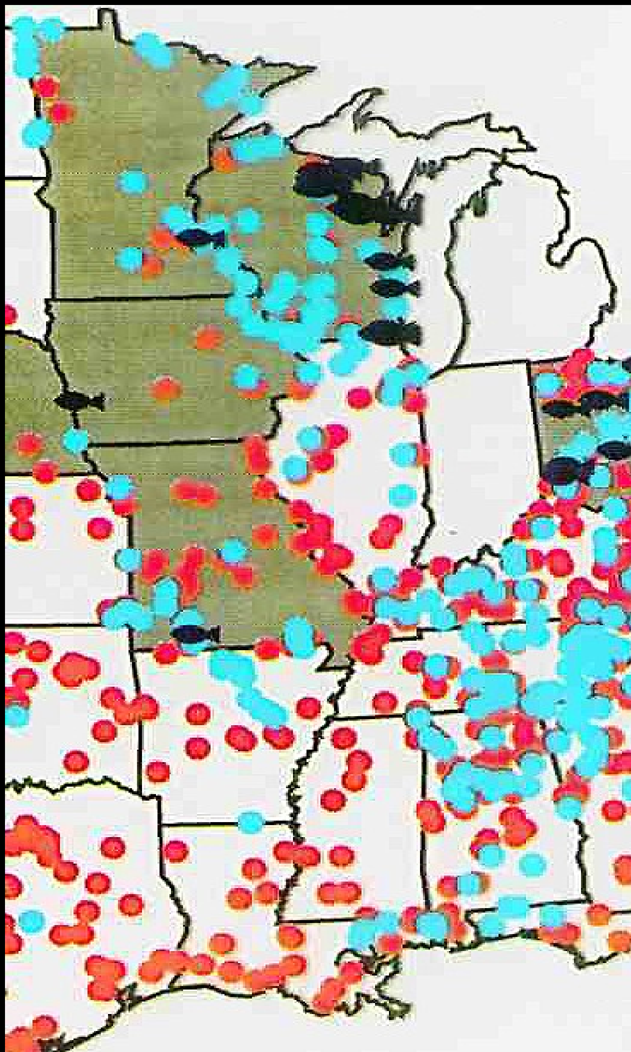
A. Terrestrial ecosystems
- Agriculture
- Forests
- Desert and desertification
- Hydrology and water resources

A. Ocean systems
1. Sea level
2. Coastal zones and marine ecosystems (including biochemical factors, e.g. acidification)

E. Human "systems"
1. Settlements, energy and industry
2. Economic, insurance, and other financial services
3. Human health
    a. Vector borne diseases
    b. Water-borne and food-borne diseases
    c. Food supply
    d. Air pollution
    e. Ozone and ultraviolet radiation

F. Atmospheric systems
1. Weather
2. Storms
3. Floods and droughts
4. Extremes

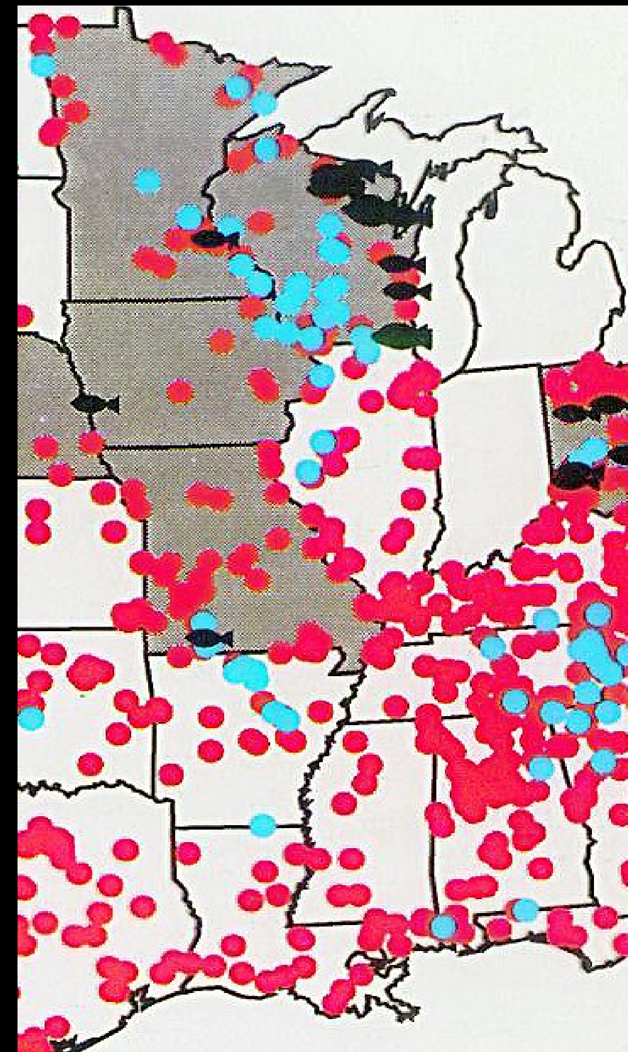
Where White Sucker could Persist



Base Climate

YES

NO

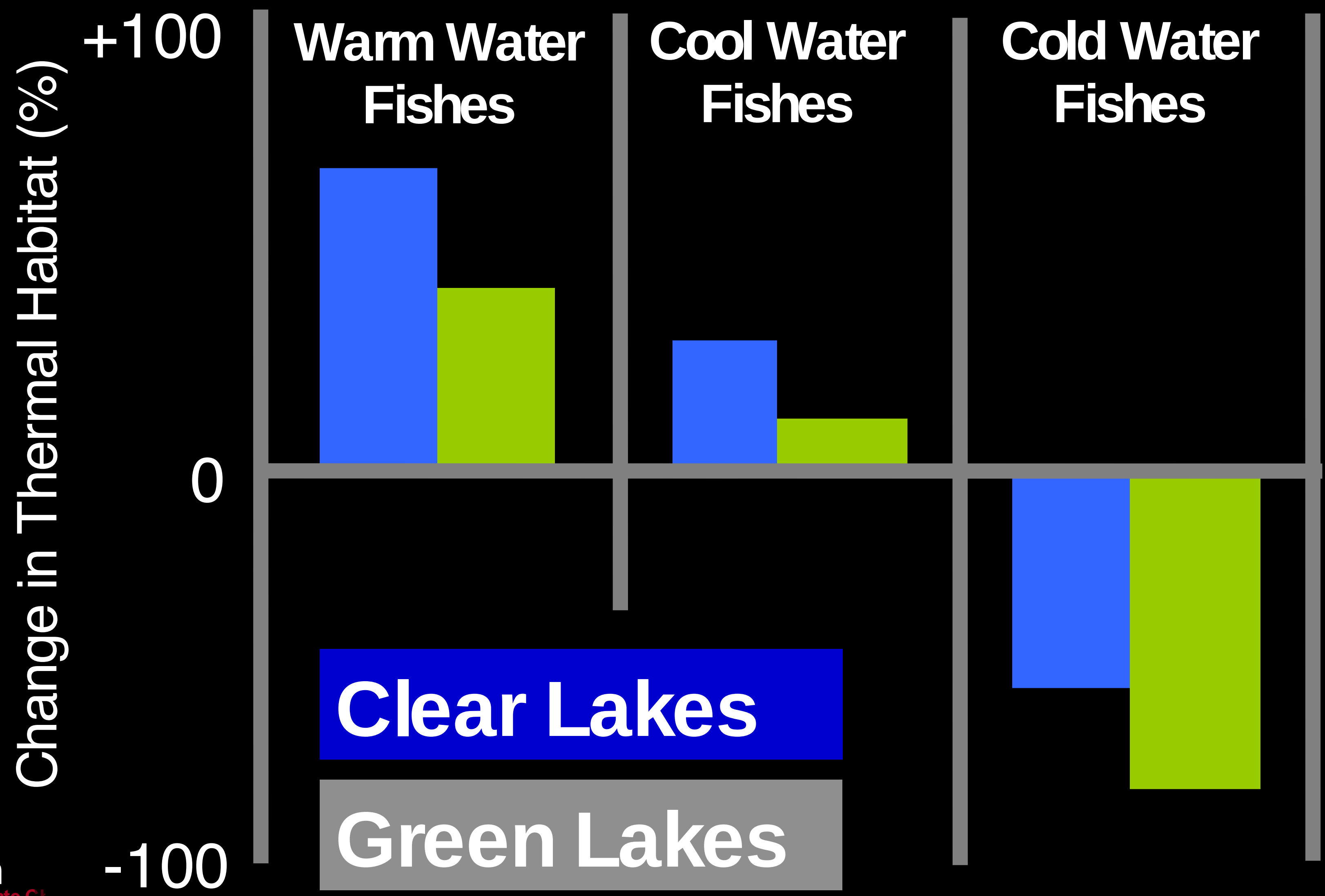


Doubled Greenhouse Gases

Global Climate Change

John Eaton and others

Minnesota Inland Lakes: Simulated Change in Thermal Habitat with CO_2 Doubling



Stefan et al.

The Changing Character of Great Lakes


Photo: USDA Forest Service

- Boreal forests likely to disappear
- Higher CO_2 and N could increase short-term forest productivity
- Higher ozone, more frequent droughts, forest fires, and greater risk from insect pests could damage long-term forest health

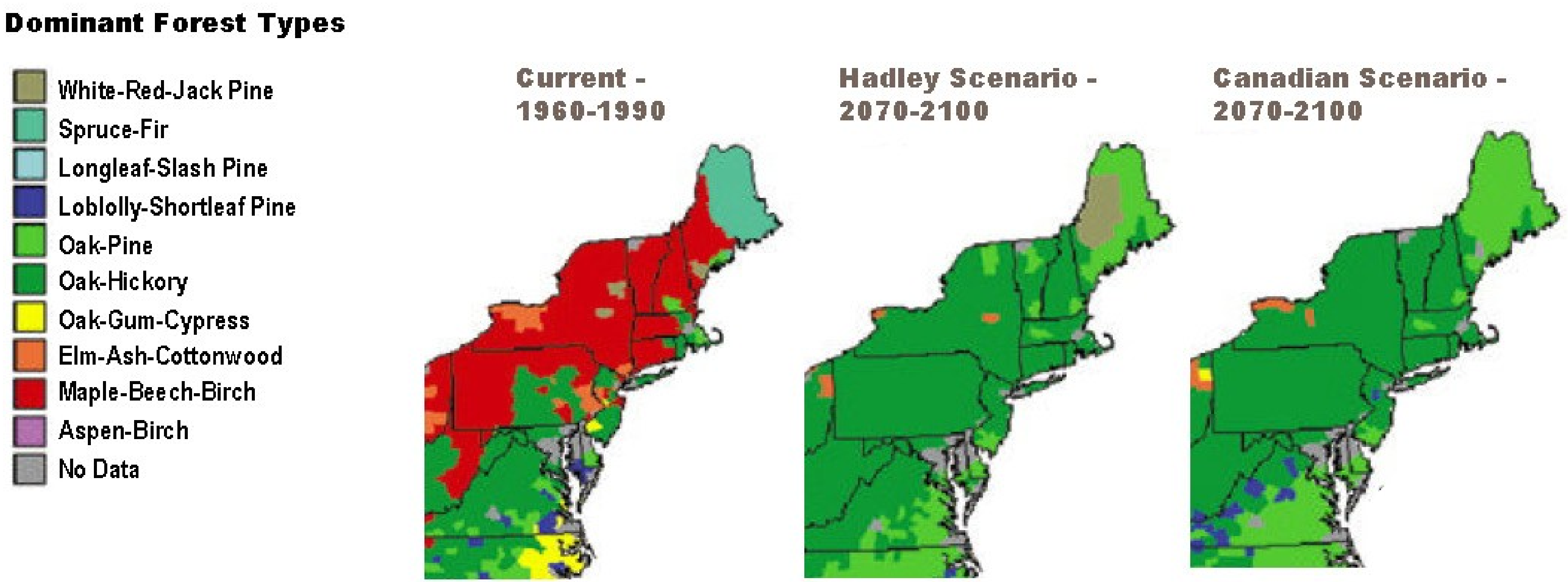

Source: J.G. Graham

- Resident bird species may benefit; migratory species will likely suffer
- Raccoons, skunks, and white-tailed deer may benefit, moose likely to suffer

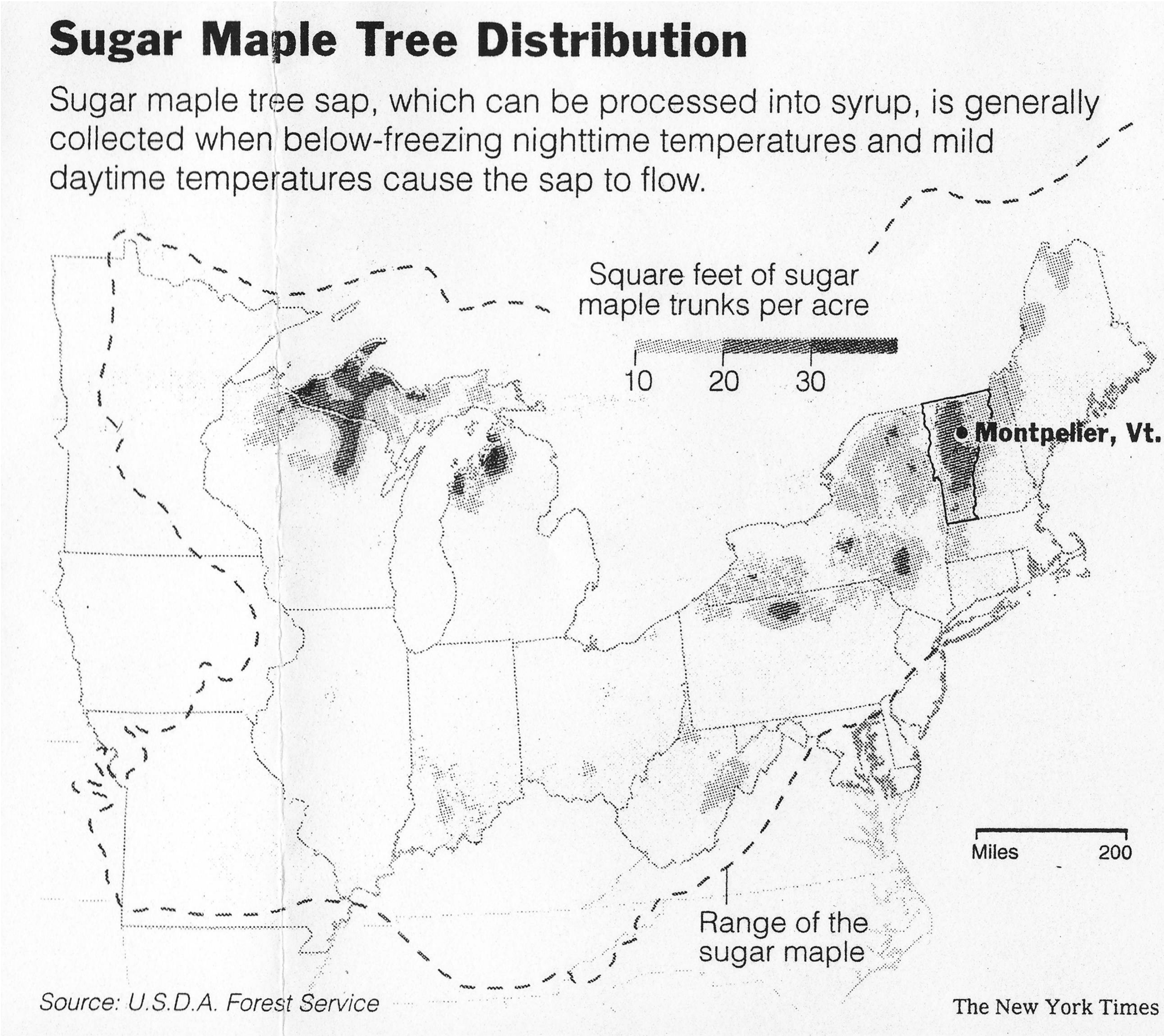
Will sugaring move north?

- © Vermont Maple Sugar Makers' Association 2005

Will we lose the maple forests?



The maps above show current and projected forest types for the Northeast, based on the DISTRIBmodel (see Forest sector). Note that Maple-Beech-Birch, currently a dominant forest type in the region, is completely displaced by other forest types in both the Hadley and Canadian climate scenarios.


Sugar Maple Tree Distribution
Sugar maple tree sap, which can be processed into syrup, is generally collected when below-freezing nighttime temperatures and mild daytime temperatures cause the sap to flow.
Square feet of sugar maple trunks per acre
10
20
30
Montpelier, Vt.
Miles
200
Range of the sugar maple
Source: U.S.D.A. Forest Service
The New York Times

Impacts on Humans

- Agriculture
- Health
- Livelihood
- Economic

Crop yields in SE Asia

Study	Scenario	Geographic Scope	Crop(s)	Yield Impact (%)	Other Comments
Rosenzweig and Iglesias (eds.), 1994[1]	GCMs	Pakistan	Wheat	* -61 to +67 *	UKMO, GFDL, GISS, and +2°C, +4°C, and ±20% precip; range is over sites and GCM scenarios with direct CO_2 effect; scenarios w/o CO_2 and w/ adaptation also were considered; CO_2 effect important in offsetting losses of climate-only effects; adaptation unable to mitigate all losses
		India	Wheat	-50 to +30	
		Bangladesh	Rice	-6 to +8	
		Thailand	Rice	-17 to +6	
		Philippines	Rice	-21 to +12	
Qureshi and Hobbie, 1994	average of 5 GCMs	Bangladesh	Rice	+10	GCMs included UKMO, GFDLQ, CSIRO9, CCC, and BMRC; GCM results scaled to represent 2010; includes CO_2 effect
		India	Wheat	decrease	
		Indonesia	Rice	-3	
			Soybean	-20	
			Maize	-40	
		Pakistan	Wheat	-60 to -10	
		Philippines	Rice	decrease	
		Sri Lanka	Rice	-6	
			Soybean	-3 to +1	
			Coarse Grain	decrease	
			Coconut	decrease	
Parry *et al.*, 1992	GISS	Indonesia	Rice	approx. -4	Low estimates consider adaptation; also estimated overall loss of farmer income ranging from $10 to $130 annually
			Soybean	-10 to increase	
			Maize	-65 to -25	
		Malaysia	Rice	-22 to -12	
			Maize	-20 to -10	Maize yield affected by reduced radiation (increased clouds); variation in yield increases; range is across seasons
			Oil Palm	increase	
			Rubber	-15	
		Thailand sites	Rice	-5 to +8	
Matthews *et al.*, 1994a, 1994b	3 GCMs	India	Rice	-3 to +28	Range across GISS, GFDL, and UKMO GCM scenarios and crop models; included direct CO_2 effect; varietal adaptation was shown to be capable of ameliorating the detrimental effects of a temperature increase in currently high-temperature environments
		Bangladesh		-9 to +14	
		Indonesia		+6 to +23	
		Malaysia		+2 to +27	
		Myanmar		-14 to +22	
		Philippines		-14 to +14	
		Thailand		-12 to +9	

IPCC Working Group II, 1996

Vector-Borne Disease Susceptibility

Disease	Vector	Population at Risk (million)[a]	Number of People Currently Infected or New Cases per Year	Present Distribution	* Likelihood of Altered Distribution with Climate Change *
Malaria	Mosquito	2,400[b]	300–500 million	Tropics/Subtropics	+++
Schistosomiasis	Water Snail	600	200 million	Tropics/Subtropics	++
Lymphatic Filariasis	Mosquito	1,094[c]	117 million	Tropics/Subtropics	+
African Trypanosomiasis (Sleeping Sickness)	Tsetse Fly	55[d]	250,000–300,000 cases per year	Tropical Africa	+
Dracunculiasis (Guinea Worm)	Crustacean (Copepod)	100[e]	100,000 per year	South Asia/ Arabian Peninsula/ Central-West Africa	?
Leishmaniasis	Phlebotomine Sand Fly	350	12 million infected, 500,000 new cases per year[f]	Asia/Southern Europe/Africa/ Americas	+
Onchocerciasis (River Blindness)	Black Fly	123	17.5 million	Africa/Latin America	++
American Trypanosomiasis (Chagas' disease)	Triatomine Bug	100[g]	18 million	Central and South America	+
Dengue	Mosquito	1,800	10–30 million per year	All Tropical Countries	++
Yellow Fever	Mosquito	450	<5,000 cases per year	Tropical South America and Africa	++

Major tropical vector-borne diseases and the likelihood of change of their distribution with climate change.

+ = likely
++ = very likely
+++ = highly likely
? = unknown

IPCC Working Group II, 1996

Stern Report – UK Government – Oct. 30, 2006 – 576pp

` *The Economics of Climate change*

Part 1: Climate change: our approach

Part 2: Impacts of climate change on growth & development

Part 3: Economics of stabilization

Part 4: Policy responses for mitigation

Part 5: Policy responses for adaptation

Part 6: International collective actions

- **Understanding international collective action for climate change**
- **Creating a global price for carbon**
- **Supporting transition to low carbon global economy**
- **Promoting effective international technology co-operation**
- **Reversing emissions from land use change**
- **International support for adaptation**

What can we do about it

- Green energy sources
- Transportation efficiency
- General lifestyle
- Advocacy

Sustainability and Energy Thoughts

News | Perspectives

From *Science* – February 9, 2007 (pages 781-813)

News

- Sustainable future, if pay up front
- Steering national lab into the light
- Put sliced solar cells on track
- Make biofuels truly popular
- Electrified froth and a fine mess
- A fuel for small farms
- Wiring up Europe's coastline
- Hydrogen econ., let sunlight work
- Take oil tanker to renewable waters
- Nuclear fuel cycle minefield
- Norway nuclear demo project
- Rethinking nature's choices
- Ex marine seeks model Empress (nuclear reactor)
- Emergence of practical biorefinery

Perspectives

- Long-term fundamental energy research
- Cost-effective solar energy use
- Engineering microbes for biofuels production
- Biomass recalcitrance: engineering plants and enzymes for biofuels production
- Ethanol for a sustainable energy future
- Renewable energy sources and realities of setting energy agenda
- Preparing to capture carbon

Greenhouse-gas emissions in 2000 by source

Energy (65%)

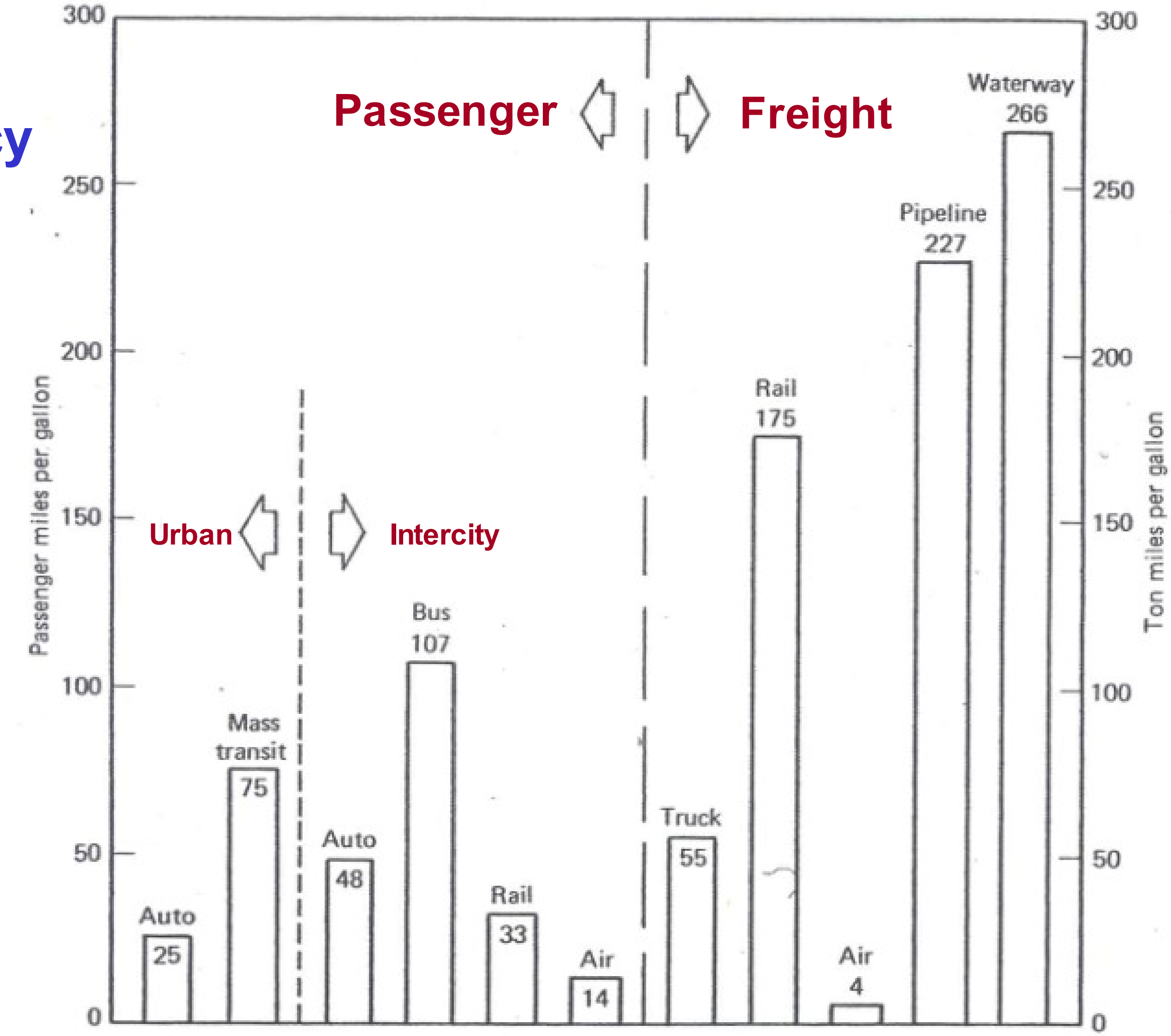
Power (24%)
Transport (14%)
Buildings (8%)
Industry (14%)
Other energy related (5%)

Non-Energy (35%)

Waste (3%)
Agriculture (14%)
Land use (18%)

From Stern Report 2006

Transportation Energy Efficiency USA Study 1974



Transportation energy efficiency. All efficiencies shown are expressed in terms of gasoline equivalent (125,000 Btu/gal = 34,839,536.62 kJ m $^{-3}$).

What Can We Do About Global Warming?

- **Recycling** saves the energy to manufacture new products.
- **Give car a day off** by riding a bike, bus, train or just walking.
- **Plant trees** – they absorb carbon dioxide.
- **Read and learn** about global warming.
- **Save electricity** by turning off the TV and lights when you're through with them and use compact fluorescent light bulbs.
- **Go solar** – a solar system to provide hot water can reduce your family's carbon emissions by about 720 pounds a year.
- **Encourage others** to take such actions.
- **Preserve forests** – they act as carbon dioxide "sinks" – in other words, they absorb carbon dioxide.
- **Develop renewable energy** technologies to reduce dependence on fossil fuels.
- **Use energy more efficiently**. For example, the federal government has voluntary partnership programs with industry to use energy more efficiently and thereby reduce greenhouse gas emissions.

Discussion and Questions

David D. Houghton
Atmospheric & Oceanic Sciences
UW – Madison
Email: ddhought@wisc.edu